Some lessons have been learnt about travel behaviour, e.g. how travel time consumption seems constant and independent of the economic and social situation and how improvements in speed increase trip length. However, although travel behaviour has been studied for many years, few theories have been developed. A theoretical approach is presented here based on the ideas that 1) transport demand is generated by dissatisfaction with one’s own space, 2) the individual tries to maximize benefit at the destination compared to utility at the origin and travel costs. Promoting sustainable transport increases the need for an extensive knowledge and understanding of individual choice behaviour and how transport consumers will react to and accept different measures. It is thus time to establish a scientific discipline for research and development in travel demand and mobility management - Mobilistics.

Four subspecialties are identified:
- **Traffic Generetics**, how travel demand is generated and satisfied under various land use structures, socio-economic conditions, policy instruments etc., including the substitution of travel by telecommunication;
- **Travel Informatics**, how to bring information to transport consumers and traffic operators;
- **Mobility Management**, how to manage travel demand, organize traffic services and analyze and evaluate the societal consequences.
- **Traffic Flow Dynamics**, how to apply IT and other techniques to control traffic flows efficiently in networks.

Mobilistics covers the behavioural sciences and transportation. Specialized professorships and university institutions ought to be established.

**Key Words:** Transport demand, Travel behaviour, Mobility management, Sustainable transport, Mobilistics

### 1.1 An eternal problem

Many ideas have been proposed and several measures implemented to solve the “eternal” problem of transport in cities. Congestion and noise problems were known in ancient Rome, and traffic restrictions such as one-way streets and the banning of vehicles were introduced in the time of Julius Caesar. The people of London experienced congested and polluted streets in the mid 19th century, and it often took less time to walk than to use horse-drawn carriages. During the era of the automobile, congestion and safety problems have been the basic reason for the implementation of new road facilities. Congestion is evident in larger cities and on main roads and causes considerable daily losses in time and costs. Accident risks have been reduced in industrialized countries, but the number of killed and injured persons is rapidly increasing in newly motorised countries, especially among pedestrians and cyclists. Noise, exhaust and visual intrusion are recognized as serious health and environmental problems in larger cities all over the world. Vehicles with lower fuel consumption and emissions have contributed to a reduction in air pollution, and some local environmental problems have been solved by traffic management schemes and noise protection measures. However, the net effect of all these efforts has not been very remarkable, as the volume of cars and trucks has steadily increased.

Some lessons have been learnt, e.g.:
- Demand for personal movement increases with higher income;
- Speed improvements lead to longer travel distances;
- Time consumption in travel seems to be constant;
- More road investments lead to more congestion.

### 1.2 The increasing demand for personal movement

In earlier times, cities were compact and most activities were available within the neighborhood because transportation costs over longer distances were high. In industrialized society, transportation technology has facilitated faster and cheaper motorized transport such as high-speed trains, jet aircraft and automobiles on motorways. The era of the automobile has led to urban sprawl with low density housing areas and a concentration of workplaces and service centers, resulting in longer travel distances, greater energy consumption and more pollution. The amount of travel kilometers in Sweden, for example, was estimated in 1910 to be 0.9 km per person and day, in 1960 to be 20 km, and today to be 45 km.
1.3 Time consumption in travel seems to be constant

Data from countries all over the world show that personal income and traffic volume grow by nearly the same proportions\(^2\). Studies also confirm Zahavi’s theory, the hypothesis that a person had the same travel time budget independent of his economic, social and geographical situation\(^3\). Even if there are variations in individual behaviour, an average of 1.1 hours a day of travel time has been found\(^4\). When income rises, people select faster modes of transport in the same travel time budget. This means that slower travel by public transport will be replaced by automobiles and, at higher incomes, high-speed trains and airplanes will be used.

A similar thesis to Zahavi’s theory was formulated in 1891 by Eduard Lill\(^5\), who stated that “it makes no difference in the matter of time consumption and travel costs if a person with wanderlust makes \(n\) short trips of \(k\) kilometers or if the person makes one journey of the same length \(nk\), as the wanderlust in both cases will be satisfied with the value of \(nk\)”.

1.4 More cars lead to less public transport service and require more road investments

The effect of increased car ownership and automobile traffic will be that the service level of the public transport system decreases and accordingly, the number of passengers dwindles. The phenomenon has been described as the *evil circle of public transport decline*. However, increased road capacity leads to more, rather than less, congestion, and travel time becomes worse for road users. In the end, an equilibrium occurs when travel time for both the automobile and the public transport systems will be equal. This phenomenon is known as Downs-Thomson’s paradox\(^6\).

Another feedback mechanism has been called the *blackhole theory of highway investment*, which describes how adding more capacity and higher speed makes it easier to travel and encourages urban sprawl, which in turn increases trip length, traffic and congestion, and requirements on more highway investments\(^7\). This phenomenon is known as Braess’s paradox: adding new routes often makes congestion worse, not better\(^6,8\).

2.1 Need for a more sustainable society

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 are the 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 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 results of the Kyoto meeting in 1997. Transportation researchers and professionals should take signals from ecologists seriously and learn about environmental problems. The epoch of “building away the problems” through large investments in road infrastructure is being seen more and more as a passed stage. Instead, a new approach is necessary in the search for measures in transportation that contribute toward a more sustainable society\(^9,10\). Among others, travel demand should be managed through a reorganization of societal structure and a more efficient use of the existing infrastructure.

2.2 Promoting sustainable transport - a great challenge today

Mannheim\(^11\) has stated that “the substantive challenge of transportation systems analysis is to intervene, delicately and deliberately, in the complex fabric of a society to use transport effectively, in coordination with other public and private actions, to achieve the goals of that society”. The focus on transportation systems analysis will be on the interaction between the transportation and activity systems of a region, and analysts must have an understanding of the basic theoretical concepts and available empirical knowledge.

The great challenge for researchers, planners, investigators and decision makers will now be on promoting sustainable transport. Examples of questions that must be answered are:
- How can travel demand and traffic patterns be forced to change in the near future?
- How can travel needs be substituted by IT, e.g. more work at home, tele-shopping, home deliveries?
- How will an advanced information society affect daily activity patterns and travel behaviour - also considering Zahavi’s theory?
- How will consumers evaluate time and costs?
- How can land use structure be changed to get higher density and proximity to workplaces, service centers etc.?
- How can short car trips be affected by a more attractive walking and biking environment?
- How can we reduce car dependency, e.g. by city renewal, by public transport, carpooling and car-sharing clubs?
- How can we introduce pro-environmental vehicles, e.g. electric cars?
- How can we affect the behaviour and attitudes of car drivers by speed limits, eco-driving behaviour etc.
- How will consumers react to traffic restrictions, increased fuel costs and other pricing measures or incentives, e.g. eco bonus?
- How will road pricing affect land use and business?
- How can IT be applied for better use of existing transport infrastructure and vehicles?
- How will transport consumers use and rely on pre-trip and on-board travel information?
- How can the political process promote sustainable transport while taking into consideration democracy, individual freedom, ethics?
- How will sustainable transport affect lifestyle and quality of life?
- How will sustainable transport influence the welfare economy and labour market?

An important issue will be to study the choice behaviour of individuals and their need and preferences for transport alternatives with reference to different policy instruments. This not only means practical experience in demo projects; theoretical approaches for establishing bases for better understanding how to influence people toward sustainable transport are also crucial.

3.1 The fundamental work of Eduard Lill

It is remarkable that one of the pioneers in travel modeling was Eduard Lill, an Austrian railway statistician who, at the end of the 19th century, analyzed data from railway ticket sales in the northwestern part of Austria. He formulated a travel law (Reisegesetz) derived from the hypothesis that there is a specific “travel value,” $M$, for an area based on the size, economic level and other qualities of the area. The connection between travel value and number of trips is given as

$$y = \frac{M}{x}$$

where $x$ is the distance (or number of travel kilometers) and $y$ the number of travelers. That means the number of travelers decreases with the distance according to a hyperbolic curve, $1/x$.

The number of travelers from an area $i$ with a given travel value $M(i)$ to a station $j$ at distance $x(j)$ is calculated by a comparison of the probability $P(j-1)$ that travelers from the area of origin will stop at stations before station $j$, and the probability $P(j+1)$ of stopping beyond the station $j$.

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

If $L(j)$ denotes the station interval, the number of travelers $y(i,j)$ from $i$ to $j$ is derived as

$$y(i,j) = \frac{M(i)}{x(j) - L(j)/2} - \frac{M(i)}{x(j) + L(j)/2} = \frac{M(i) \cdot L(j)}{x(j)^2}$$

Lill denoted his observations as a law of Nature analogous to Newton’s law of gravitation in physics. However, it has a fundamentally different theoretical approach.

3.2 Contributions in the 1950s and 1960s

Models for calculating trip distribution, based on comparisons of Lill’s probabilities theory, were developed and used in the 1950s and 1960s. They are known as the intervening opportunity model, presented by Schneider at the Chicago Transportation Study, and the competing opportunity model, presented by Tomazinis. Gravity models for the prediction of trip distribution have been developed and applied by Voorhees and Morris, who used, in a Swedish traffic forecasting study, a gravity model with a double-constrained iteration for trip generation and attraction at each zone. These types of models are still used for aggregated trip estimation.

3.3 Later theories of individual choice behaviour

Travel surveys in later years are directed toward analyzing data in a disaggregated way to find relationships between behaviour, individual socio-economic factors and the choice situation. Stated preference studies are used, e.g. for analysis of willingness to pay for improved transport service and the acceptance of road pricing. Another field has been the determination of fare elasticities for different travel characteristics.

A wide variety of general decision theories and rules exists in the behavioural sciences and in consumer economy. However, few contributions have been made in the field of individual choice behaviour in transport. Disaggregate predictions of travel behaviour have been presented by Mannheim and a general framework for individual travel choice behaviour has been described by Ben-Akiva and Lerman, who stated that a decision maker is faced with a set of feasible discrete alternatives.
and selects the one that yields the greatest utility viewed as a random variable. Logit models are used for predicting how travelers make stochastic choices between different alternatives, e.g. between means of transport (modal split). Another problem has been the development of models for how drivers choose routes in a traffic network. Theories on stochastic multiple route choice have been formulated by Dial\(^2^1\) and by Gunnarsson\(^2^1\).

The following theses are an approach to a theory on how individuals express their demand for transport and how they make strategic travel choices.

**Thesis 1: Mobility is a part of the activity patterns of individuals**

The daily activity pattern of an individual consists of a series of things done outside the home sphere, e.g. going to work, shopping, visiting friends. These activities generate a need for movement - on foot or by vehicle - in order to gain physical access to specific destinations. Some of these activities are bound or forced in space and time, e.g. going to work and school or to 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. Some of the trips are also bound to a trip chain, meaning a combination of stops to satisfy a set of errands, e.g. when returning home from work, also making a stop at a shop and then picking up children at the day nursery before reaching home. The activity pattern and corresponding movements can be described in space-time diagrams, as was demonstrated by Hägerstrand\(^2^2\).

**Thesis 2: Transport demand is generated by dissatisfaction with one’s own space**

The demand for movement is formulated here as: “Transport demand is generated by dissatisfaction with one’s own space at a certain moment, event or situation” A transport demand is defined as the need for something which can not be satisfied in the present sphere. The individual must therefore make a set of decisions in order to gain access to a specific activity and satisfy a given need: to move or not to move (perhaps use the telephone instead), to what destination, at what time, in whose company (alone or together with others), by which mode or combination of modes, by which routes, to which stop (station or parking space). All these decisions are linked together in a complex chain of choices, some already made before the trip is started, e.g. going to work at a given time, while some can be changed during an ongoing transport, e.g. taking a different route than planned or even changing the destination.

**Thesis 3: The individual tries to maximize expected utility in movement from one place to another**

In rational decision making, the individual tries to maximize both the total and subtotal benefit in relation to the positive and negative consequences of each decision. The decision maker evaluates alternatives momentarily, arbitrarily or routinely, and primarily identifies consequences in a short term perspective. This means that more direct, immediate factors, e.g. time savings, have a higher ranking than long term consequences, e.g. risks for a serious injury. The strategy for a decision maker to move from an origin point to a destination point will be based on an evaluation of:

a) the known utility \(U(i)\) at the point of origin \(i\);

b) the estimated or expected utility \(u(j)\) at destination point \(j\) depending on the type of errand: it can be directly measured in receiving salaries for work trips, in time and money savings for shopping trips, or in social values directly or indirectly for meetings and visits;

c) an expected sacrifice or “travel cost” \(c(ij)\) - in time, money, physical effort, discomfort, risks etc. - incurred by the movement from \(i\) to \(j\) by a selected means of transport, also including return costs.

The logical result of such a decision to move (or not to move) to a selected destination should therefore be that the expected net benefit \(b(j)\) is greater than the travel costs,

\[ b(j) = u(j) - U(i) > c(ij) \]

However, there are also factors that are non-rational or are not included in the costs, e.g. walking for the sake of one’s health, use of a longer but more scenic route, avoiding traffic signals or traveling for fun without having a defined destination. We therefore insert an additional factor \(a(ij)\) as an expression for such behaviour,

\[ b(j) = u(j) - U(i) + a(ij) > c(ij) \]

The decision process can be seen as an optimization problem for the individual,

\[ b(j) = \max \{ u(j) - U(i) - c(ij) + a(ij) \} \]

As mentioned earlier, the expected utility and the costs are given by uncertainty but are in many cases known to the decision maker.
**Thesis 4: Travel decisions are made with consideration to many constraints**

Decisions in travel are related to a set of individual and societal constraints which will influence the choice of destination, departure time, transport mode and route:

- **Type of need**, e.g., buying a product used on a daily basis does not require a selected evaluation of destinations, while a seldom-purchased product means a more careful selection of one or more destinations, or carrying a number of packages;
- **Access to transport service**, e.g., existing public transport, transport service for the disabled, disposition of a private car or bike;
- **Dependency on other travelers**, e.g., family members, car-poolers;
- **Ability to move**, e.g., as a biker, being free of handicaps and walking problems;
- **Opportunity for or necessity of combining a trip with other errands**, e.g., to bring children to school when going to work, travel with friends;
- **Opportunity to select a desired destination**, e.g., lack of public transport service, lack of facilities for the disabled, restriction of business hours;
- **Opportunity to select a desired means of transport**, e.g., traffic restrictions, parking regulations or lack of parking facilities, vehicle failure, lack of driving license;
- **Opportunity to make a selection at a desired time of departure and arrival**, e.g., traffic congestion, temporary transport inadequacy due to weather conditions, lack of public transport at certain hours, fear of walking during night hours;
- **Necessity of arriving at a given time**, e.g., to an appointed meeting, to a theater;
- **Time available**, related to stress and shortage of time (which will influence the choice of destination, mode of travel, risk taking);
- **Specific preferences**, e.g., need for privacy in transport, unwillingness to drive a car, demand for comfort and seating;
- **Economic resources**, e.g., how much money the individual is willing to pay for a specific transport in relation to time savings, and the consequences of traveling or not;
- **Information available**, e.g., on timetables, travel costs, park-and-ride, parking facilities and parking costs at the destination;
- **Force of habit**, e.g., unwillingness to change habits, habits by routine;
- **Personal awareness**, e.g., consideration to risks, environmental protection.

**Thesis 5: Modeling should be based on discrete variables**

In modeling, it is assumed that the individual makes a rational choice between alternatives. To describe different behaviour, the potential users of a transport system are classified according to many specific categories related to discrete variables, e.g., into car owners and non-car owners, family structure, income level. However, as shown in thesis 4, there are many constraints that must be considered in the application of both deterministic and stochastic models.

Further research is necessary to develop theories on the behaviour of individuals in travel choice situations and to increase an understanding of how individuals react to regulation, pricing and information measures and incentives (“pull and push”).

### 5.1 Need for a special discipline

Research in transport demand and behaviour of travelers has long been carried out. A great deal of knowledge and experience is available in transport demand management, traffic flow control, para-transit solutions and mobility management. It now seems reasonable to establish a scientific discipline directed toward developing theories, analyzing travel behaviour and organizing transport service. A special purpose is the need for extensive studies on how the transport sector should contribute to sustainable development. I thus propose “mobilistics” as a special scientific discipline devoted to studies in person movement, analogous to logistics for material handling and goods transport.

Mobilistics fulfills the criteria for a scientific discipline as it represents a defined theme (or niche) in which all aspects of reality and problems are noted and there is need to increase and improve knowledge. Education, textbooks and methods are available for gaining and increasing knowledge in the area, and networks exist for communication between researchers for the exchange of concepts and research results or for critique and peer reviews through seminars, conferences, journals etc. However, there is a need for specialized professorships and university institutions.

Mobilistics is not directly related to research and development in transportation technology or to the construction of traffic facilities. The idea is to study the pos-
sibilities for managing travel demand within an existing infrastructure. However, it will be necessary to define the need for a reorganization of existing land use and transport infrastructure.

5.2 Four subspecialties

Mobilistics as a scientific discipline foremost covers four highly integrated subspecialties in the behavioural sciences and transportation (Figure 1).

Traffic generetics

includes studies of how travel demand is generated and satisfied under various conditions and constraints with reference to socio-economic conditions, traffic service conditions, pricing methods etc. Further in-depth studies are necessary for an understanding of the behaviour of individuals in different choice situations and in order to formulate and evaluate theories on travel demand. It is also necessary to find methods to predict changes in travel behaviour that depend on the introduction of new policy instruments for traffic regulation and pricing with a special focus on achieving more pro-environmental transport. Such studies have been demonstrated e.g. in the EU 4th Framework project of TRANSPRICE. How telematics can be used and accepted for substituting travel through teleworking, teleshopping etc. is another area to be studied further and followed up in demo projects.

Travel informatics

includes studies of how to bring information to different decision makers all over the transportation field for transport consumers and traffic operators. The application of IT in the transportation field will influence vehicle engineering, traffic operation, traffic control and enforcement, and the supply of information to customers. Examples of applications are pre-trip information on transport alternatives (means of transport, departure and arrival times, route choice, parking fees and road tolls), and on-board information to drivers or public transport travelers about present road and traffic conditions, route changes, delays, transfer possibilities etc. Research is being done on how new technology can be adapted to humans and used in a reasonable and acceptable way from the point of view of personal integrity and ethics. The “KomFram” system in Göteborg, Sweden, is an example of a system implemented for both information to travelers and operators of the public transport system.

Mobility management

includes studies of how to manage travel demand and organize traffic services, mostly with respect to existing land use and traffic infrastructure and how to reduce dependency on private cars. Examples of mobility management are implementation of car and van pools, car clubs for ownership sharing, delivery service (also by use of public transport), and promoting walking and biking. Organization of mobility centers at both the regional and local levels (at workplaces and companies) will be an essential part of a programme for marketing and promoting sustainable transport, as has been shown e.g. in the EU 4th Framework project of MOMENTUM. Another example is the establishment of mobility centers at the neighborhood level serving households with home deliveries, post service, the transport of children, the elderly and disabled persons, travel information, information on and organization of car sharing and car pooling, bike rental and service, return transport for environmental recirculation etc. Further research and development are necessary to find ways to organize new transport alternatives in order to reduce the dependency on private cars and to achieve an effective use of existing vehicle capacities. Methods must also be further developed for analysis and evaluation of the societal consequences of such measures, e.g. in terms of effects on quality of life, land use, the economy, the labour market, the environment, safety and security etc. It is also of interest to follow up the implementation process and the acceptance of measures.
Traffic flow dynamics

includes studies of traffic flows in networks on the micro level, analyzing capacity, efficiency, safety and environmental consequences. The main objective is to establish the effective use of an existing transport system through regulation and control of traffic flow as a support to transport demand management and mobility service. This specialty has long been of interest, and a variety of methods are available, among them the often used CONTRAM system for dynamic simulation. Further research and experience would facilitate an optimal real-time control of traffic flow in both the public transport system and the automobile system. The application of artificial intelligence and expert systems will here be of great interest for monitoring and controlling traffic flows.

A new approach is necessary in the search for measures to contribute to a more sustainable society. To meet this challenge, there is need for more extensive research in travel behaviour, in how to organize transport service and in how to analyze and evaluate the societal consequences of different measures. A special scientific discipline is proposed - here called mobilistics - for studies of travel demand and mobility management as a contribution to sustainable transport.

Mobilistics can be considered a scientific discipline as it covers a niche of transportation issues, because theories and methods are already available or are in networks, and because education, organizations and networks are established. However, there is a need for specialized professorships and university institutions in mobilistics.


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