https://doi.org/10.26552/com.C.1999.4.29-36



Hermann Knoflacher *

# NAPRIEK 110 ROKOM LILLOVHO ZÁKONA - 110 ROKOV ZÁKLADNÝCH CHÝB V DOPRAVNEJ VEDE

## IN SPITE OF 110 YEARS OF LILL'S LAW - 110 YEARS BASIC MISTAKES IN TRANSPORT SCIENCE

*Lillov zákon z roku 1889 implicitne obsahuje tzv. „časovú konštantu" pre mobilitu, ktorá sa v posledných desaťročiach objavuje v mnohých empirických štúdiách na celom svete. Môžeme vidieť, že Lillov zákon sa dá odvodiť zo zákona ľudského správania sa, ktorý objavili Weber a Fechner v 19. storočí. Poznanie tohto zákona nám umožní lepšie pochopiť mechanizmus moderných dopravných systémov a ľudského správania a nájsť riešenia, ktoré spolu navzájom súvisia.*

*Lills law, published 1889 includes implicitly the so-called "time constancy" for mobility which was found in many empirical studies during the last decades, worldwide. It can be shown that Lills law can be derived from a more basic human behaviour law, discovered by Weber and Fechner in the 19th century. The knowledge of this law helps us to a better understanding of the mechanisms of modern transport systems and to find solutions which are more cause-related.*

In 1889 Eduard Lill, a senior Inspector of the k.u.k. Austrian "Nordwestbahn", published the "Basic Law of Person Transport" (1). This law was based on Lill's observation that tickets for shorter railway trips were sold more often than tickets for longer railway trips. Analysing the statistics of his observations, he derived the following fundamental law:

$$M = R \times d \qquad (1)$$

Here $M$ is defined as the so-called "Travel Value". $R$ is the number of trips going out from a village or a city and $d$ is the distance of these trips (Fig. 1). If the number of inhabitants does not change and also the economic conditions remain the same, the "Transport Value" $M$ is constant. Lill proved this law by analysing the Statistical Data of the Austrian "k.u.k. Nordwestbahn" and the "Süd-Nord-Deutsche Verbindungsbahn". Lill's law is well known in Transport Economics and Transport Planning since this time. It has been taught at many Universities - but obviously it has not been understood in a proper way. The fast development of the mechanical transport modes in the last two centuries has not left enough time to study and, therefore, understand the system effects properly. If Lill's law and his ideas would have been used as a basis for further studies, the transport sector and transport planning might have developed in a quite different way.

After the Second World War, the European transport science became dominated by the American view. The Europeans were very impressed by the American Transport System and followed uncritically what the US Transport Science produced and recommended. So the European view of the transport system was narrowed down. It was reduced to motorized cars forgetting all the other modes. The transport science became an ideology, a kind of religion and was taught at the Universities in this way until today. The Highway Capacity Manual became a kind of bible for traffic engineers and transport planners. The reality was not seen anymore and so the ground for unbelievable mistakes was prepared.

Because only parts of the system were seen, the system effects were not understood and not recognized. The outcome of this process is obvious today: Degradation of quality of life and increase of environmental problems. The discipline which promises solutions, transport planners and traffic engineers, can be identified as the ones which produce and maximize transport problems. The greater the transport and environmental problems become, the more attempts are made to solve them. But instead of solving the problems, the mistakes are enlarged. Since social science is already criticizing the technicians, they are acting like a religious society, aggressive and trying to suppress their counterparts. They believe in dogmata without being able to prove them on a scientificly sound basis. The more their arguments became unbearable, the more they react ruthless and aggressive and try to support their untameable basic hypotheses by supporting sub-hypotheses around an empty centre of their discipline.

* **Univ. Prof. Dipl.-Ing. Dr. techn. Hermann Knoflacher,**
Institute for Traffic Planning and Traffic Engineering, Technical University of Vienna, Grosshaustrasse 30, Vienna

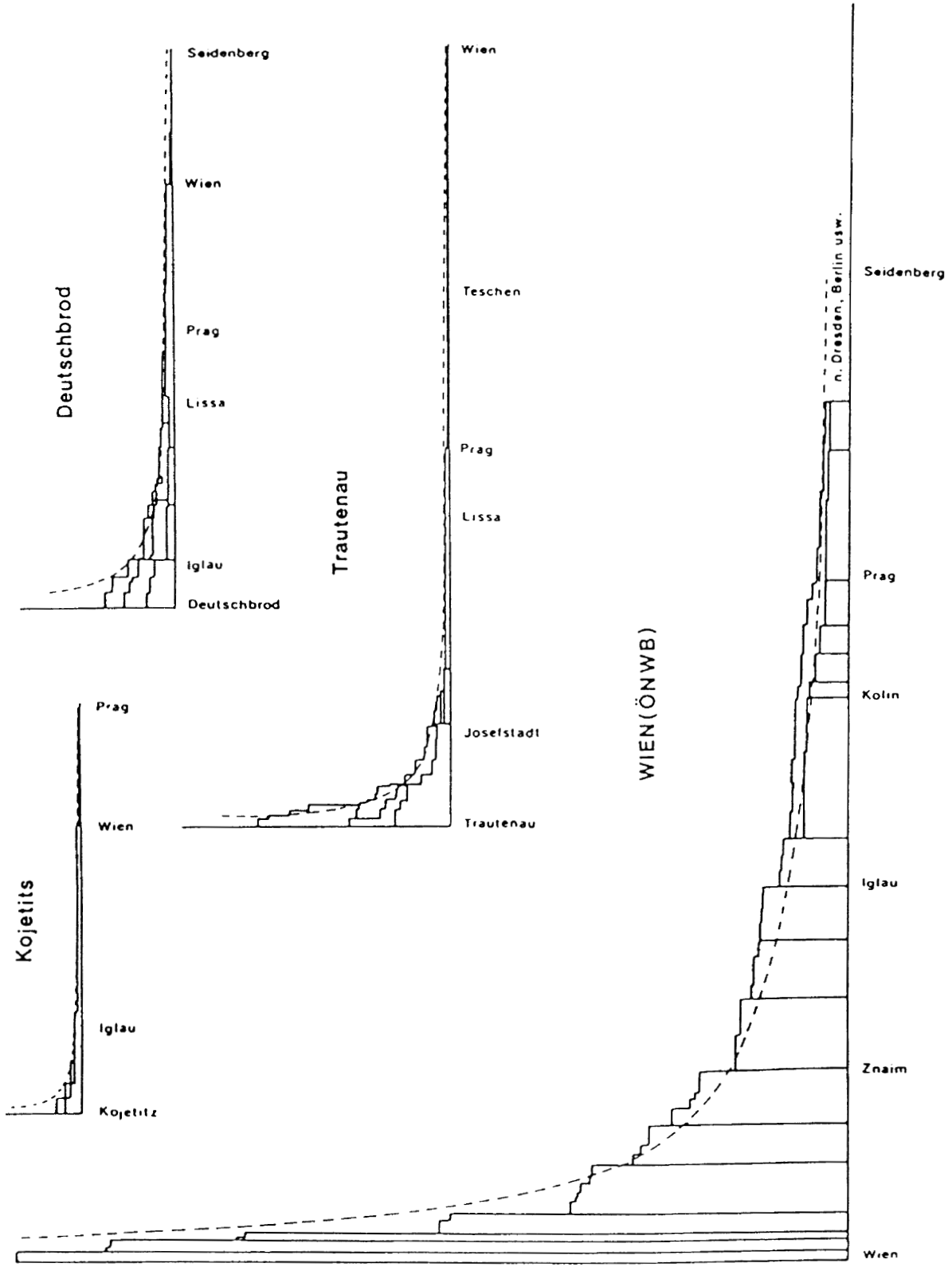
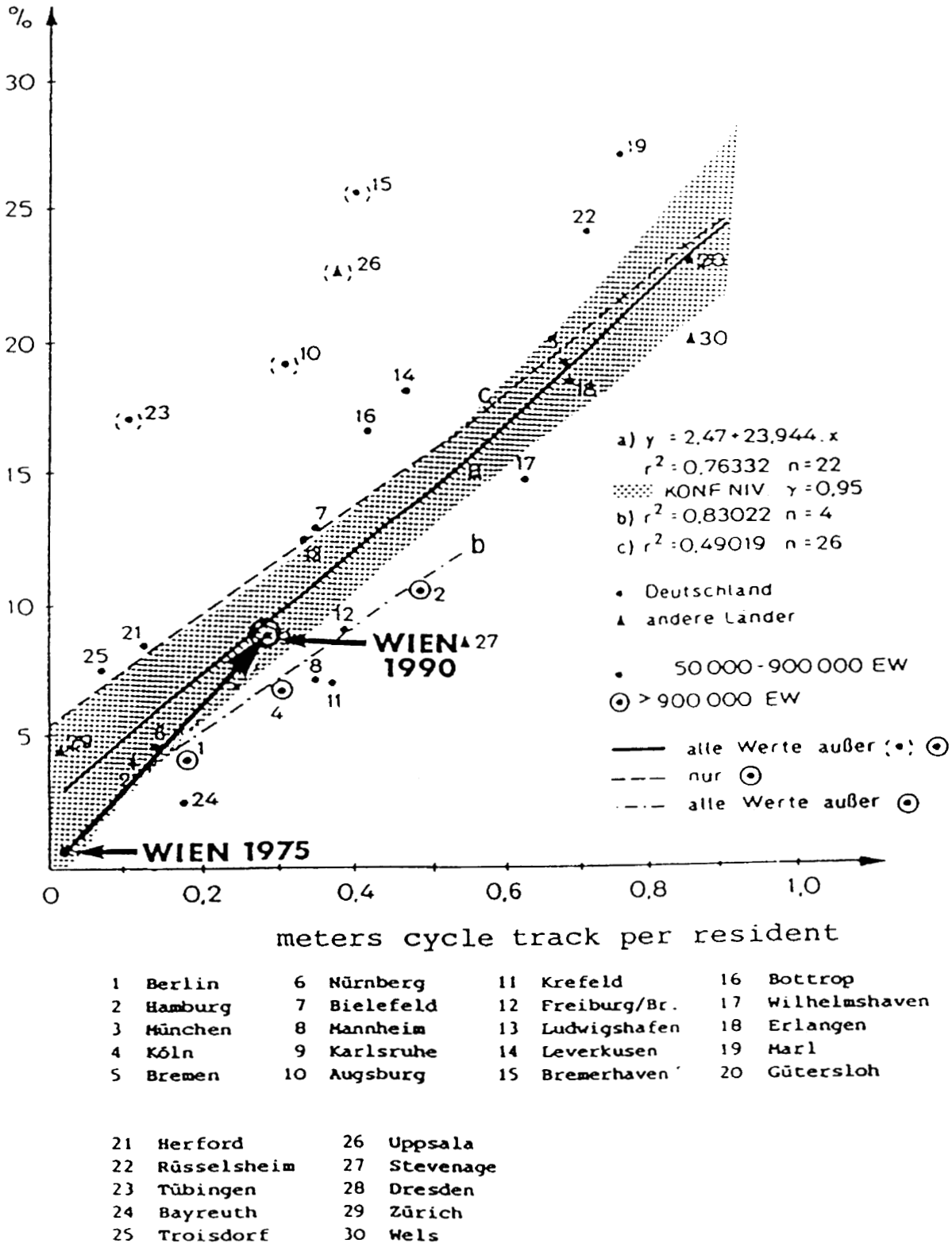



*Fig. 1 Number of travellers in the year 1887 on selected railway routes in the Austro-Hungarian monarchy - Vertical axis: R = 425 000 (indication for the first column)*




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | Berlin | 6 | Nürnberg | 11 | Krefeld | 16 | Bottrop |
| 2 | Hamburg | 7 | Bielefeld | 12 | Freiburg/Br. | 17 | Wilhelmshaven |
| 3 | München | 8 | Mannheim | 13 | Ludwigshafen | 18 | Erlangen |
| 4 | Köln | 9 | Karlsruhe | 14 | Leverkusen | 19 | Marl |
| 5 | Bremen | 10 | Augsburg | 15 | Bremerhaven | 20 | Gütersloh |

| | | | |
|---|---|---|---|
| 21 | Herford | 26 | Uppsala |
| 22 | Rüsselsheim | 27 | Stevenage |
| 23 | Tübingen | 28 | Dresden |
| 24 | Bayreuth | 29 | Zürich |
| 25 | Troisdorf | 30 | Wels |

*Fig. 2 Mutual relationship between the choice of transport mode - cycle - and the meters cycle track per resident*
*Source: KNOFLACHER, H.; KLOSS, H.P.: "Radverkehrsanlagen: Ergebnisse einer Erhebung". Straßenverkehrstechnik, Heft 4/1979. (Page 115).*

The main dogmata in transport science are based on personal experience. They can be proved by personal experience, but they can not be proved for the whole transport system. Most transport engineers believe that their personal experience is the system effect. An example to show that this is absurd: No human being is able to run at a speed of 50 or 130 kilometres in an hour using only his own body energy. But it is possible to drive at this speed on the road. Now they believe that their senses, which are the senses of pedestrians, are able to reproduce the system effects of the nowadays fast transport system. It is interesting that at the Fourth International Road Conference in 1923 the estimation for the maximum future speed on motorways was 45 kilometres per hour (Table 1). In the last 150 years transport engineers have created a transport system operating at high speeds but without understanding the real effects of their activities. The whole system is founded on beliefs and assumptions without any scientific sound basis.

The following main dogmata are the foundation of traditional traffic engineering.

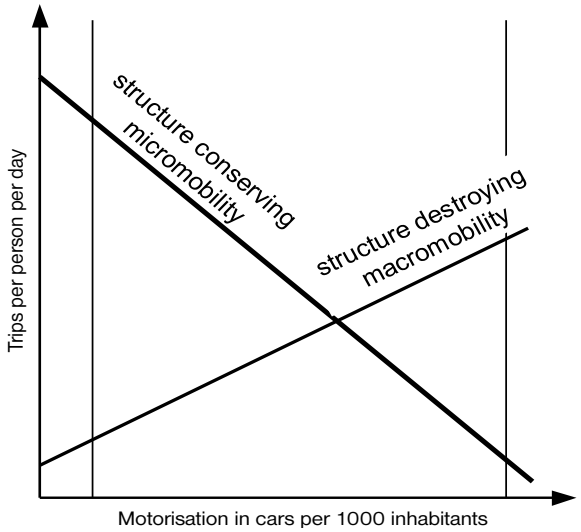



*Fig. 3 Micromobility - Macromobility*
*Source: Knoflacher, H.: Landschaft ohne Autobahnen; Böhlau Verlag, Wien 1997.*

## Growth of Mobility

The narrow view to consider only motorised car traffic, produced the impression that mobility is growing because the term "mobility" was identical with car driving. The causes for mobility were not understood, although traffic planners are using the gravity law to calculate the number of trips. The cause for mobility is always a potential, a need for something that can not be found in the nearby environment. To compensate the deficits of the surrounding structure, mobility is necessary. So mobility is driven by the basic needs of the society. If the basic needs are not changing, the number of trips is not changing. This is exactly what numerous studies, carried out worldwide, show us today. The number of trips per person and per day is not changing with increasing motorization. What is changing is the kind of mobility. The number of trips and, therefore, mobility is a constant figure (as it can already be seen in Lill's law). If car mobility is increasing, all other kinds of mobility are decreasing. The "mobility" itself remains constant. There is no growth of mobility in one mode without a decline of the same amount in other modes. What was done before using the modes pedestrian, bike or public transport is now done using a car. In 1975, a basic study carried out by Knoflacher/Kloss improved the understanding of this effect (Fig. 2). When cycle tracks are provided or built, cycle trips are "produced". So the kind of mobility can be changed by changing the environment (Fig. 3). The "growth of car mobility" is nothing more than the transformation of public space, which was used by everyone before, to a privileged space for car drivers for parking and driving. So the term "growth" is absolutely wrong. Car mobility is not based on a natural law and, therefore, the growth is not natural. Car mobility is produced. The precise expression is, therefore: "Production of car mobility". This leads to the question: Who is responsible for this production and, therefore, the increase in accidents, air pollution, noise etc? This important question has not been asked until today

Definition of maximum speed at the 4th International Road Conference in 1923 Table 1

| | Maximum speed [km/h] | | | | |
|---|---|---|---|---|---|
| | | Ordinary roads | | Special roads | |
| Total load [kg] | Iron tyres | Solid rubber tyres | Pneumatic tyres | Solid rubber tyres | Pneumatic tyres |
| 3001-4500 | 12 | 25 | 35 | 30 | 45 |
| 4500-8000 | 8 | 20 | 30 | 25 | 40 |
| 8000-11000 | 5 | 15 | 20 | 20 | 30 |
| more than 11000 | 5 | 5 | 10 | 15 | 20 |

## Conclusion

If Lill's law would have been understood the mistake to believe in the "growth of mobility" would have been avoided.

**"Time savings"**

If somebody is driving from A to B and uses a faster mode, he recognizes that he needs less time. Transport planners and traffic economists, in principle the whole transport sciences, use this effect for the calculation of benefits from "time savings". All Cost Benefits Analysis are based on this assumption. Investments in fast transport systems must, therefore, produce a lot of benefits for the society. No deficit in the transport system can occur, because the calculations are based on the benefits inside the transport system alone.

The faster the transport system in a society is operating, the more time is saved and more time is available for other things - the society must become very pleasant and relaxing. But this is totally in contradiction to what everybody can observe. In the meantime, it is well known and deeply studied on sound scientific work that increasing the speed of the transport system does not change anything in the overall mobility-time of the whole system. The mistake of traditional transport science is the assumption, that personal experience can reflect system effects. No more than an atom can understand the effects of a molecule, which it is forming together with others into a system, no more personal experience of transport system users can understand the system effects. Today, it can be taken as proved that there are no time savings possible by increasing transport speeds (Bendtsen/Schmidl/Meier/Knoflacher). There is no empirical evidence anywhere that the increase of speed has reduced overall travel times. But there are quite a few other effects. Since travel time is not changing, the distance is changing. This can be found everywhere in the world. Fig. 4 shows one empirical example. The structure is changing while the speed of the transport system is changing. Human tradition is based on the pedestrian and his settlements. If the speed is enhanced in an artificial system, which is not following the laws of our universe due to economic deformation of the physical reality, structural changes are unavoidable. There are two sides of the coin. First, cities spread mainly for housing, because everybody wants to live in the green. On the other side a concentration of activities like trade, work etc. is appearing - but in the new system these activities are no longer connected to the city or the village. The destruction of villages and cities is unavoidable.

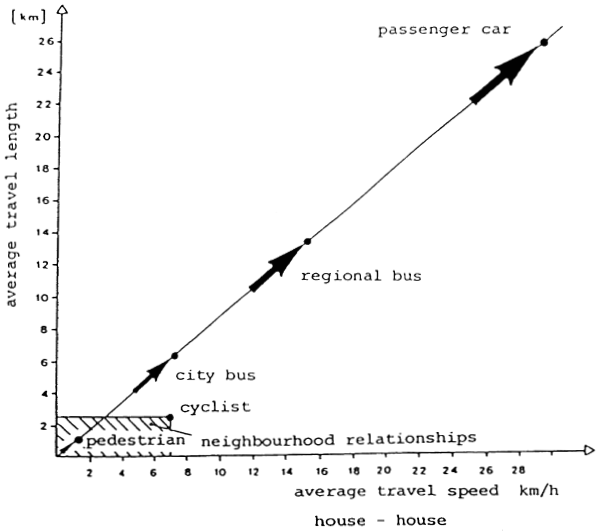



*Fig. 4 Relationship: average travel speed - average travel length (empirical results, survey Salzburg 1982)*

The constancy of travel time is included in Lill's law. This fact was not seen by the scientific society for more than hundred years. In the belief of doing the best, transport engineers and planners have destroyed traditional high quality settlement structures and degraded them to "machine sheds without roof". The most of the public space is blocked and controlled by machines - namely cars. This is extinguishing all other city activities and, therefore, extinguishing city life.

**Understanding Lill's law a little bit better**

Transport engineers are trained to believe on physical terms, like distances, time or any indicator as such. They are not educated to understand the human behaviour. So, it is interesting to analyze Lill's law a little bit deeper: Nobody is travelling a certain distance without any reason. The distance in Lill's law can not be seen as the reason for a trip. It must be something else. If we try to calculate the total number of trips for a certain settlement, a village, a certain person etc., we have to integrate the function, shown in equation 1 ($h$ is the number of trips while $l$ is the trip length):

$$h * l = c \qquad (\text{c = constant}) \tag{2}$$

$$h = \frac{c}{l} \tag{3}$$

The total number of trips we derive is as:

$$H = \int h * dl \tag{4}$$

$$H = c * \int \frac{dl}{l} \tag{5}$$

and finally:

$$H = c * \ln l \tag{6}$$

So the total number of trips is nothing else than the logarithm of the "trip length".

In 1843, Weber analyzed human sensation and found the so called Weber's law of human sensation in relation to the intensity of irritation. This law was finally improved in 1880 by G.T. Fechner and has the form:

$$E = h * \ln I \qquad \begin{array}{l} \text{E ... Human Sensation and} \\ \text{I ... Intensity of Irritation.} \end{array} \tag{7}$$

Weber/Fechner's law has the same mathematical expression as Lill's law. What Lill has discovered was nothing more than the

relationship between human sensation and the stimulation caused by the environment for the transport system. This describes also the background and cause of Lill's law: It is not the length, it is the stimulation over the length, which makes people moving. The stimulation is always complementary to the stimulation on the spot. Stimulation on the spot or at the origin is called "demand". Stimulation at destination is called desire, "wish" or "demand in a positive sense". Stimulation at the origin is demand in a negative sense. If this would have been understood a hundred years earlier (Knoflacher 1995), we would have a totally different transport system and a totally different kind of engineering.

## Traditional education in transport science

Transport engineers believe that problems in car traffic are serious, congestion is seen as negative and a serious problem and the economists calculate time losses from congestion as financial deficits. The reason for this misunderstanding can be found in the factors explained in this paper and in the traditional approach to the transport system, narrowed by the American Highway Capacity Manual and its translation into other languages. Transport planners are educated to use only level of service A - E and to absolutely prevent level F. On the other side, they make their demand oriented transport planning by establishing a certain planning level of service (between A - E). The Capacity $C$ is put into relation to the actual and future traffic flow $V$ and $V + \Delta V$.

$$\frac{V}{C} = los_i \tag{8}$$

If traffic flow is increasing, they try to extend the space for car traffic to keep the same level of service. This basic assumption can be expressed as in Formula 9.

$$\frac{V}{C} = \frac{V + \Delta V}{C + \Delta C} = los_1 \tag{9}$$

The capacity of the existing system is enhanced by $\Delta C$.
If we introduce the changes of traffic volume we get Formula 10.

$$V(t + \Delta t) = V(t) + \frac{dV}{dt}\,\Delta t \tag{10}$$

If you put Formula 10 into 9 we get 11 and finally 14.

$$l + \frac{dV\,.\,\Delta t}{v\,.\,dt} = 1 + \frac{\Delta C}{C} \tag{11}$$

$$\frac{dV}{V} = \frac{\Delta C}{\Delta t\,.\,C} \cdot dt \;\Big|\int \tag{12}$$

$$\ln V = \frac{\Delta C}{\Delta t\,.\,C} \cdot t + k \tag{13}$$

$$V = ke^{\frac{\Delta C}{C} * \frac{t}{\Delta t}} \tag{14}$$

The traffic volume $V$ is increased as the effect of traffic engineering activities always putting more capacity into the existing system and, therefore, creating exponential growth.

Traditional traffic planning is, therefore, the cause of exponential growth of car traffic. But there is also another way to explain the totally wrong education of transport engineers in traditional transport science. The intensity of stimulation for the traditional educated transport engineer is car traffic "growth". The information comes from traffic counts, which means counting car traffic, and the reaction is to provide more infrastructure for car traffic. So the behaviour of the transport engineer is influenced by his own sensation in a clearly specified way. If the stimulation from car traffic is increasing, he has learned to react with adding some capacity to the existing system. If we describe this behaviour of transport engineers or the traditional transport science (traditional worldview) we get Formula 15.

$$\underset{\substack{\uparrow \\ \text{Sensation of} \\ \text{Administration Engineers} \\ \text{Politicians, Public}}}{E} = \underset{\substack{\uparrow \\ \text{Car Traffic}}}{\ln l} \tag{15}$$

If we introduce the terms the way administration, engineers etc. react, we get Formula 16.

$$\pm \frac{\Delta C}{C} = \ln V \tag{16}$$

It is easy to recognize that Formula 16 is nothing more than a version of Formula 14. So, traditional transport teaching, transport science and transport engineering is the cause for the exponential growth of traffic problems and not the solution.

## Solution:

A solution can only be successful if we prevent basic mistakes:

1. No "growth of mobility".
   Only the kind of mobility can be changed from sustainable to unsustainable or in the opposite direction.
2. Changes in Parking Organisation:
   Since human behaviour was not understood, traditional transport engineers were taught to solve the problem where there is no solution possible - at the flowing part of the transport system. Problems in transport flows are not the causes. They are only the effects of underlying causes. As it was discovered by Knoflacher in 1981, the organisation of parking is the cause of most of our transport problems. As long as cars can be parked close to the human activities, there is no solution possible (Fig. 5). The first step of a real solution of the transport problems is, therefore, to introduce a parking regime which makes transport regulations meaningful and effective. So, at least the distance to the parked car for each of the activities must be as long or longer as the distance to the next public transport stop (Fig. 6). The structure has to be changed in parking. If we change this structure, the city structure will become stable and many transport problems will disappear. Parking is the key to the

solution of the transport problems. Attempts to solve problems in transport flow, including telematics are a kind of symptom treatment. A completely wrong organized transport system can not be improved by introducing a sophisticated information system on a totally wrong point of the system structure. Lot of research is going in the absolute wrong direction due to the lack of understanding of the system by all professions dealing with the transport system. We are losing time, we are losing money and we are losing understanding.

3. There is no "growth of mobility" if we count mobility in the number of trips, there is only a shift of mobility between different modes. There is also no "time saving" in the system, by increasing speed.

The solution is the change of parking regulations, a solution at the source.

*Reviewed by: V. Medelská, P. Surovec*

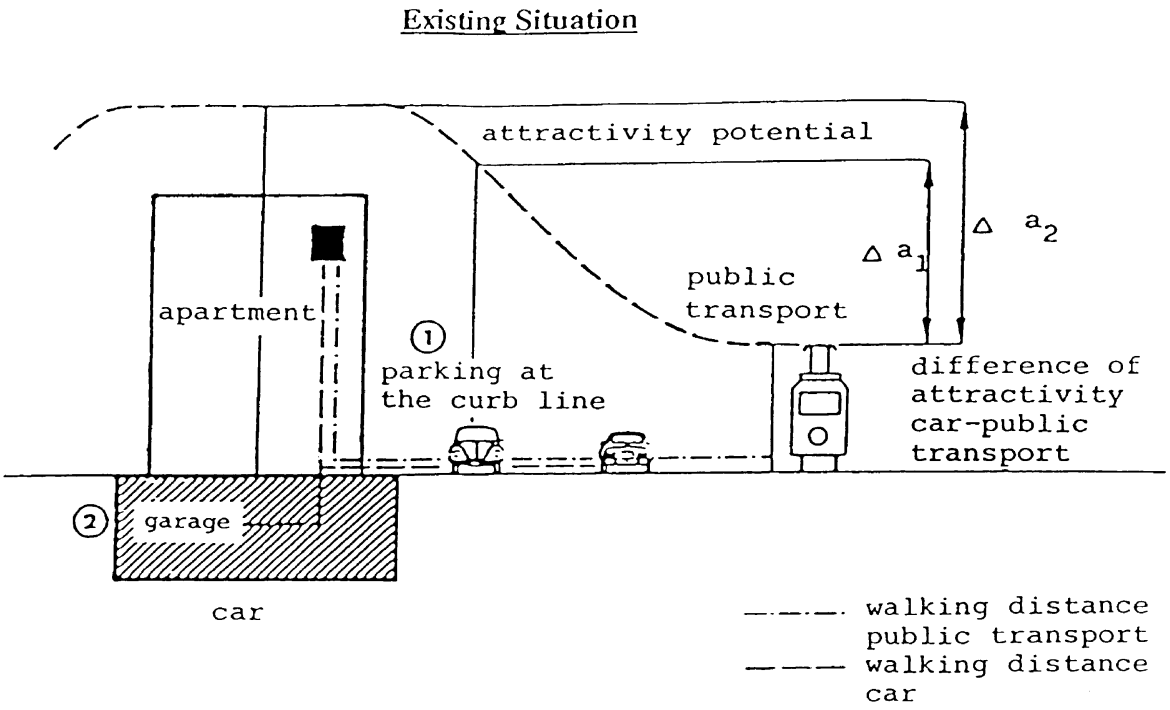



*Fig. 5*

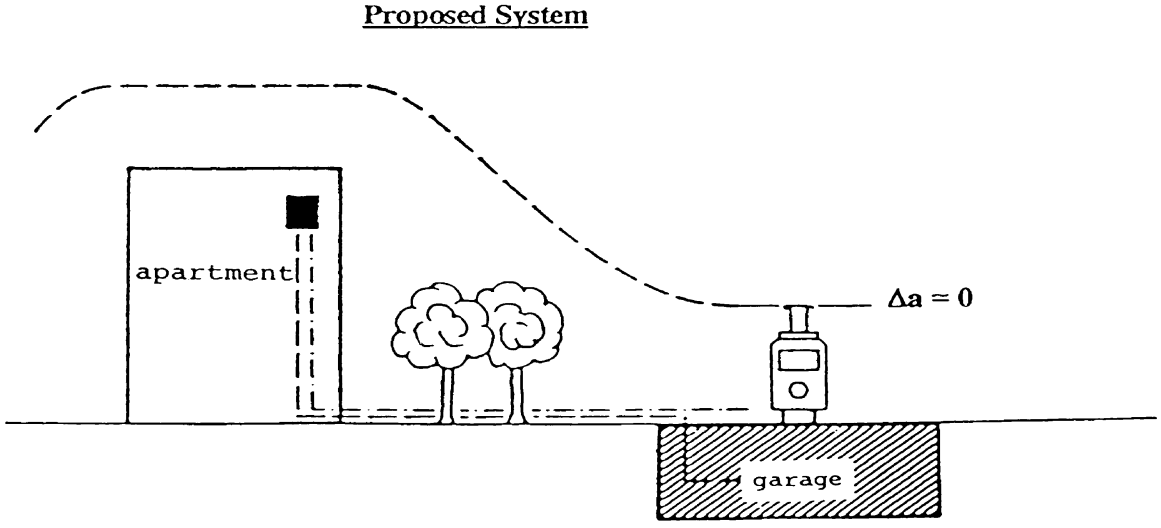



*Fig. 6*

## References

[1] LILL, E.: Die Grundgesetze des Personenverkehrs; Zeitschrift für Eisenbahnen und Dampfschiffahrt der Österreichisch-Ungarischen Monarchie, Wien 1889.
[2] KNOFLACHER, H.: Second International Symposium on Highway Capacity; Do we use the "Level of Sercive" Concept in the right way? August 1994, Sydney, Australia.
[3] KNOFLACHER, H.: MOBILITA 95 - Slovenska technicka univerzita Bratislava; Das Lill'sche Reisegesetz - das Weber-Fechner'sche Empfindungsgesetz - und was daraus folgt. May 1995, Bratislava.
[4] BENDTSEN, P. H., 1968: Byplanleagwing. Kopenhagen.
[5] MAIER, E., 1989: Neuverkehr in Folge Ausbau und Veränderung des Verkehrssystems. Dissertation an der ETH Zürich. Schriftenreihe des Instituts für Verkehrsplanung, Transporttechnik, Straßen- und Eisenbahnbau (ITV) der ETH Zürich; Nr. 81, Zürich.
[6] SCHMIDL, H. 1990: Mobilitätskennziffern des werktäglichen Personenverkehrs im räumlichen und benutzergruppenspezifischen Vergleich. Dissertation an der TU-Wien, Fakultät für Bauingenieurwesen.
[7] SPIEGEL, T. 1992: Die Empfindung des Widerstandes von Wegen unterschiedlicher Verkehrsmittelbenützung und deren Auswirkung auf das Mobilitätsverhalten; Dissertation an der TU-Wien, Fakultät für Bauingenieurwesen.
[8] KNOFLACHER, H. 1985: Katalysatoren für Nichtmotorisierte. Eigenverlag, Wien 1985.
[9] KNOFLACHER, H. 1987: Verkehrsplanung für den Menschen, Band 1 Grundstrukturen. Orac Verlag Wien.
[10] KNOFLACHER, H. 1993: Zur Harmonie von Stadt und Verkehr - Freiheit vom Zwang zum Autofahren; 1. Auflage 1993. Böhlau Verlag Wien.
[11] KNOFLACHER, H. 1995: Fußgeher- und Fahrradverkehr, Planungsprinzipien. Böhlau Verlag Wien.
[12] KNOFLACHER, H. 1997: Landschaft ohne Autobahnen - Für eine zukunftsorientierte Verkehrsplanung. Böhlau Verlag Wien.
[13] KNOFLACHER, H. 1981: Human Energy Expenditure in Different Modes: Implications for Town Planning, International Symposium on Surface Transportation System Performance; US Department of Transportation, October 1981.
[14] KNOFLACHER, H. 1986: Kann man Straßenbauten mit Zeiteinsparungen begründen? Internationales Verkehrswesen 38. Jg. Heft 6