



Mobility and Transport for our tomorrow roads



Which future for our mobility?
(Source: ilmondo.fotoblog.it)

During the years of my youth, near the fateful '68, there is no doubt roads were considered one of the essential factors for the economic, social and cultural development of the human society. Only benefits were expected from a new road. In the two decades between 1970 and 1990 this assumption has been gradually called into question up to 2000, when some thinkers and environmental associations started contest about any new road construction.

My work as a young and enthusiastic engineer before and later on as a professor trainer of new engineers was deeply called into question; this questioning was about its meaning and its ethic consequences. After all, it was the same problem that bioethics had created in biology and medicine.

This science tries to solve problems arising from the relation between the applications of technical-scientific research from one side and the consequences on human life from the other one.

Introduction

The problematic was defined in an improper but efficient way as environmental bioethics [1]. However it appeared clear that answers to its questions would affect the life of a growing number of people. So, this study was born from the need to go deeply into the value of the work I chose, in particular trying to answer the question "When, how much and how are roads useful?" The matter - just like it's simple to imagine - is almost complicated and articulated. It involves many subjects and it needs the point of view of many cultural approaches. For this reason I can't assert to have taken on fully the answers. Anyway with time, some circumstances have become clearer through many dialogues and elaborations so that it is now possible to state some remarks and intuitions which represent steps to a path towards a goal

which seems achievable but has not yet been reached.

This article comes out from the need - shown to me by many people - to explicitly and organically publish the remarks and intuitions expressed in some conferences and only partially explained in previous papers. Some of them are not scientifically proved, but only reasonable within a not yet confuted hypothesis. I hope - in future - to have new data, multidisciplinary contributes, time availability and resources to define the whole matter in a better way.

The mobility is not only a derived need

Transport has been considered for a long time exclusively as a derived need, related to the need to satisfy other primary needs. In this direction commuting and freight transport for commercial purposes represent



the classical examples. Anyway, in recent years, studies - published in many circumstances - affirm mobility satisfies also a primary need of human beings.

On the other hand, the pleasure of walking in the "old town" of a city or of getting to a mountain dew through a mountain trail are just some of the possible examples of experimental evidence of the nature of that primary need. Substantially mobility has a positive intrinsic utility or, in other words, the demand for mobility has also a non-derived component [2 to 6]. This idea is persistent in some secondary lines of Research and confirmed by the everyday experiences, but it is often ignored by the current scientific paradigm.

Reducing the matter to a schematization of two opposing hypotheses, one would have:

1. The traditional reductionist approach, that travel is only an expression of a derived demand:

- so it has only a negative utility;
- reducing travel brings about only benefits;
- policies must be adopted to reduce congestion, increasing travel costs or making origins closer to destinations.

2. The extended experiential approach that travel has also an intrinsic positive utility, which may sometimes lead to:

- the fact the travel is just the activity you want to do, *i.e.* travel itself is an activity;
- moving is the reason for the activity, while the destination appears secondary to the movement;
- the desire for travel can generate the trip itself.

This second type of travel can be described as indirect travel and it is characterized by the following two conditions:

- there is a movement in space;
- the destination is secondary to travel itself.

Mokhtarian affirms [2, 3, 6] the usefulness of a travel is decomposable into three components:

- a) the utility of the activity to be carried out at the destination (the one traditionally considered);
- b) the usefulness of the activities that take place during the trip (listening to music, talking with a friend, thinking or relaxing, talking on the phone, working with a laptop, reading, but also the activities of driving, etc.);
- c) the intrinsic utility of travel itself.

Experience suggests that the last two components are sometimes clearly present

and cannot be ignored. So, the extended experiential approach - which takes into account all factors - seems more reasonable.

For this reason it will be considered later in next sections of this work.

Mobility is an innate human need

Proving that mobility is an innate human need, according to the rules of the scientific method, is a very difficult undertaking. However, it's possible to be convinced this is true from some important clues. These come from paleo-anthropology and sociology.

Although researchers don't agree on what uniquely distinguishes the human evolutionary line, the paleo-anthropologists traditionally considered the bipedal gait as the distinguishing feature that separates the ancestors of human beings from the anthropomorphic apes.

Bipedalism, in fact, is one of the unique features of the human race [7], as already Lamarck stated in his "*Philosophie Zoologique*" (1809).

Whatever the factors that led to the acquisition of upright posture (which took place about 6 million years ago), it is indubitable that it has been a prerequisite for the emergence of truly human forms.

This is documented in two consequences:

in this new position, the neck could support a much heavier weight of skull than quadrupeds. This opened the way to the enormous development of skull (happened about 2 million years ago) that is observed in our species.

Secondly, the fore legs, no longer needed for walking, could be used for the production of tools. Bipedalism was the initial adaptation, the one that opened the way to all others [8 to 10].

Rules adopted by human societies of all times give us with the second clue.

In fact experience teaches us prison has always been the most "natural" limitation for human beings. Its most obvious feature is the restriction of mobility. So, for each man free mobility is one of the first freedoms that must be guaranteed by the civil society, in response to this obvious primary need of mankind (Figure 1).

These indications therefore converge

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towards the hypothesis that mobility is the concrete expression of a native need of human being.

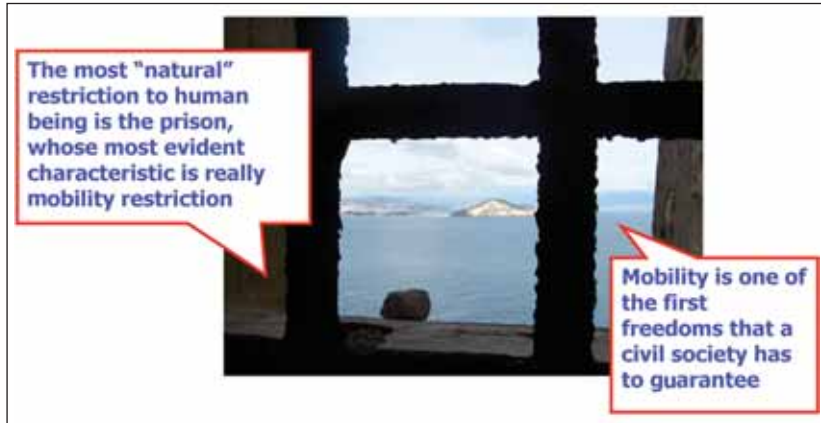


Figure 1
Mobility: one of the first freedom
(Source: www.flickr.com)

The significance of the innate need for mobility

Why does a human being, as such, feel this inevitable need for mobility? Obviously it is not easy to answer this question. The experience once again helps us to consider that a possible key to understanding is the wish for knowledge. It is implied by the expectation of novelty and the search for a meaning of world and existence that each human being, as such, carries inside. This fact seems to emerge from the following considerations and examples, ranging from Prehistory to nowadays.

First of all, for the non-derived mobility it's not important the reason of the travel, but the movement itself. So, when the movement takes precedence in itself, it means that the cause is not outside the person, but it's located within her. Therefore, we have to look for psychological causes.

A first hypothesis, related to paleo-anthropology, is the following.

The need for mobility for a human being is linked to the need to support the Ego. In fact, reality becomes dynamic through the movement. The transition from static to dynamic involves interactions. During this process human being perceives the existence of the Ego in action. This is also amplified by the fact that, in general, we do not know what we face as a result of the movement.

The certainty of a lack of knowledge of a different space in the future stimulates the need for knowledge by the Ego. In this process, human beings acquire the certainty of perception of themselves in action and, therefore, assert their Ego. This assertion becomes more complete if, as a result of the movement, a derived activity is generated. In this case the activity doesn't generate the mobility as a necessity, but on the contrary, the mobility can lead, as a consequence, to the activity. This interpretation could explain the shift from Homo to Man, a change from a movement without conscience to a conscious one. The "quid" characterizing Men could thus be their "cultural" activities, caused by the movement. In the case of mammalian quadrupeds this step never happened; the only case in nature is Man, bipedal mammal: statistically it's not enough to consider valid the hypothesis that the Bipedalism is crucial. However, there is no doubt that if the only case found is related to Bipedalism, this will be a clue not to be neglected.

A second hypothesis is that non-derived mobility has a component which corresponds to the desire for something that is not readily available. In this case, the mobility tends to a not yet available accessibility. Anyway, even if we improve accessibility, there will always be a desire for mobility towards something else beyond the new accessibility we have achieved.

An extreme example is the desire of flying that mankind has ever had, while being aware that human body is unable to do so. It's possible to give some examples. The arrival in Australia (Figure 2) dates back to around 60,000 years ago.



Figure 2
The travel toward Australia

At that time, due to a different level of seas, to reach this continent it was necessary to cross a sea of at least 70km. This implies the capacity to build vessels ingenious enough to face open sea. But why did those people have to embark on this risky adventure? Haven't they got sufficient land on which finding sustenance? Just in this we can recognize something of our own humanity: this curiosity which pushes away from known areas and places to see what there is beyond the horizon, in search of remote and mysterious locations. On the other hand, classics have often described this state of mind, from Sophocles to Dante. The desire for knowledge is what often able to create the capacity for action, as Sophocles [11] describes very well.

*"Wonders are many,
and none is more wonderful than man;
the power that crosses the white sea,
driven by the stormy south-wind,
making a path under surges that threaten
to engulf him, (...)
and Earth, the eldest of the gods, the immortal,
the unwearied,
doth he wear, turning the soil with the offspring
of horses,
as the plows go to and fro from year to year."*
(Sophocles, Antigone)

Ulysses is probably the most famous traveller of all time. Homer's poem presents him as the king of the island of Ithaca. During the siege of Troy he was noted for his smartness: he thought the trick which enabled the Greeks to win the war. His return journey lasted ten years and was terribly troubled. His figure has intrigued artists of all ages and all styles. In particular, Dante Alighieri [12] stands him as a symbol of the human thirst for knowledge. Persons who wish to understand mobility should reflect on the Dante's work describing Ulysses' voyage beyond the columns of Hercules (Figure 3). In a recent film (*The Truman Show*, 2000) the protagonist is kept confined from birth in a television set especially built like a small town. All actors go and play in this virtual world while the protagonist lives, without knowing, in this huge Candid Camera. Here he is surrounded by all the attention and he doesn't lack anything. Anyway, also because of the desire to leave

for a trip he was inexplicably denied, he notices the deceit. So, the desire for knowledge of the outside world is stronger than the certainty that the well-being is guaranteed by the virtual world. For this reason he prefers to face the unknown that lies behind the meaning of a true life, abandoning forever the set (Figure 4).

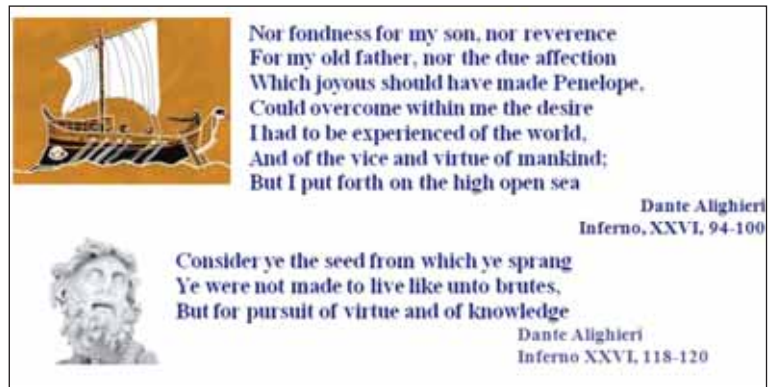


Figure 3
Dante describing Ulysses' Trip
(Source: www.agenziaulisse.it)

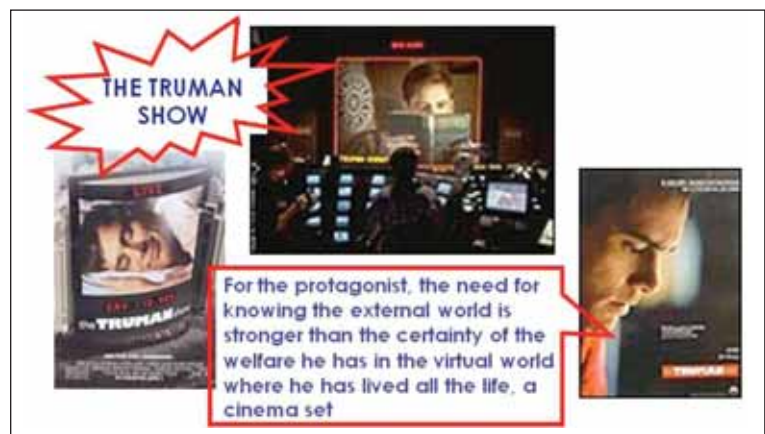


Figure 4
Is always mobility a derived need or is also a native human need?
(Source: From the film "The Truman show" www.aepsi.it)

The measure of mobility

Mobility can be measured both in terms of time (e.g. average time a person devotes to mobility in one day), and of space (e.g., how many km a person covers in a year). The estimates have to be made from surveys, or some people have to be specially monitored. In any case, data processing has some problems, due both to the significance of samples in relation to the population considered, but also to the possible arbitrariness of the interpretation of the views expressed from the sample since they need to be converted from a qualitative >>>

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to a quantitative way. There is also the difficulty of obtaining valid data, which are derived by combining length of trips with speed and travel time of modes of transport. There are many possible errors in these calculations [13]. However, since such measurements were made in many countries already since 1970, it is possible to try and provide some interpretations.

The desired time of mobility is constant

First of all it is possible to consider data related to mobility time measurement. Already in 1980, Zahavi and Talvitie [14] had identified the law of the constant travel time (TT), which states that the average time spent on mobility in one day is constant over time and between different groups of people, and it is also independent from the travel mode. In fact (Figure 5) plotting mobility average time of people living in different places of the world versus their income, it is possible to see that the average time is practically independent from income and quite close to a bit more than one hour per day.

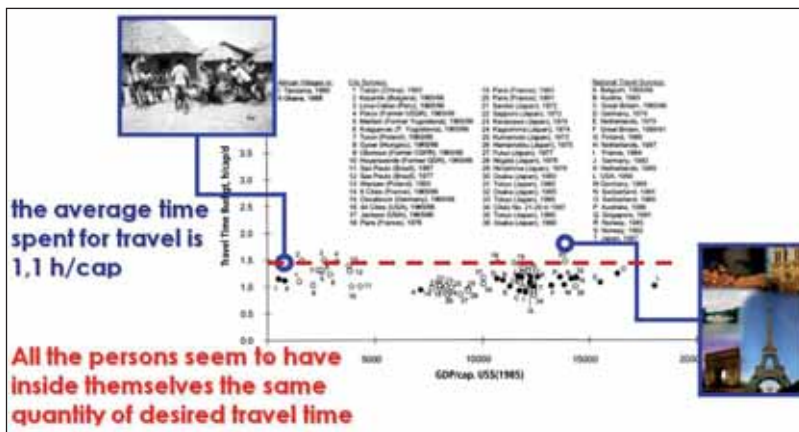


Figure 5 (from Schafer, A., [15])
Desired travel time expenditure

The existence of this law is confirmed, in turn, by many hints, deriving from the experience and the human cultural tradition. For instance, Marchetti [16] points out that taking the map of the villages of ancient Greece into account and overlapping areas of individual villages so that their centres coincide (Figure 6), the area of a typical village corresponds to a square of about 3km side. In this case, walking from the end to the centre of the village and back (probably the typical average travel distance villagers at that time) takes about one hour.

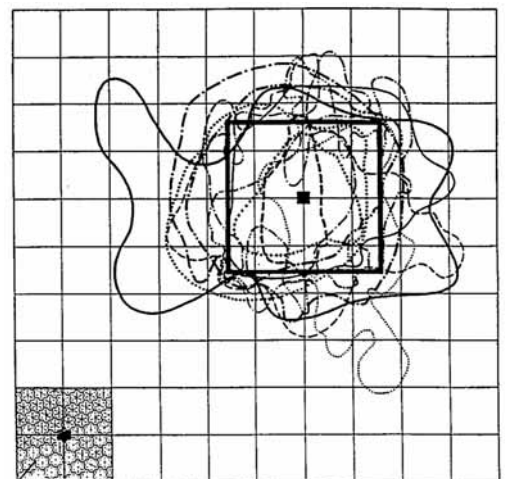
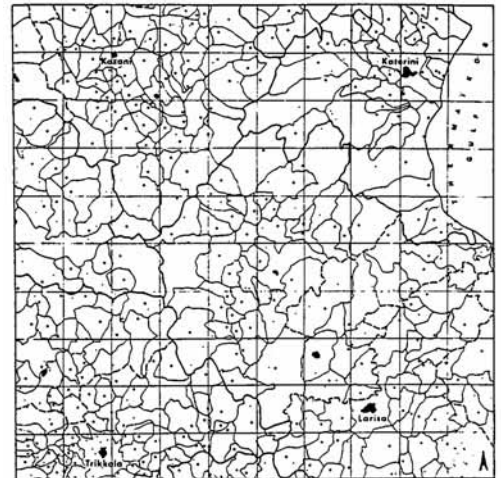


Figure 6 (from Marchetti, C. [16])
The dimension of the villages in the ancient Greece

On the other hand, the same Marchetti [16] takes into consideration how the size of the city of Berlin have changed in time and he puts them into relation with the different modes of transport available in their respective points in time (Figure 7).

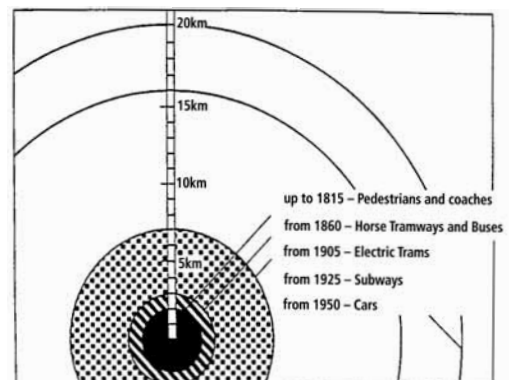


Figure 7 (from Marchetti, C. [16])
Development of Berlin

This analysis shows that the size of the city has always been governed by the possibility for the inhabitants of the suburbs to go to downtown and come back in a time of about one hour. As soon as faster modes of transport became available, the city expanded to reach the size corresponding to the possibility of going to work and return home each day in about one hour.

Moreover, even in the already mentioned example of the prison, in order to make the restriction and punishment more human, the chance of one hour of "out-of-cell time" during each day is offered to prisoners. On this occasion a prisoner is allowed to move, even if in a confined space, for a time that is universally recognized fair, if it is equal to an hour.

Moreover Schafer [17] mentions the data of Szalai [18] according to which it is quite obvious that the time spent moving in one day on average is just over 1h/a day and does not vary very much when daily working time changes (Figure 8).

However either in Paris or in an African village, the average time of mobility is approximately equal to 1.1 hour per day.

On average, each person seems to have within herself/himself the same amount of desire for mobility: if she/he moves much more or much less, she/he suffers.

The law of travel time constancy has been analyzed critically, among others, by Hupkes [19], Vilhelmsen [20], Marchetti [16], Akerman [21], Höjer and Mattsson [13], Schafer and Victor [22], Mokhtarian and Salomon [2], Mokhtarian [6], Schafer [15], Levinson and Wu [23].

Many remarks refer to the possible uncertainty of data and to the fact that the law holds at an aggregate level while variations can be very high at the level of the individual. However, some researchers have tried to identify the possible explanation of the law. In particular Vilhelmsen [20] provides a biological explanation presuming that human being maintains stability in her/his conduct. According to this explanation it is possible to say that people have been spending rather the same average time for travel each day from the earliest days in history. Therefore human nature is biologically programmed by evolution to keep doing so. This explanation is further developed by Marchetti [16]. He states that the stability

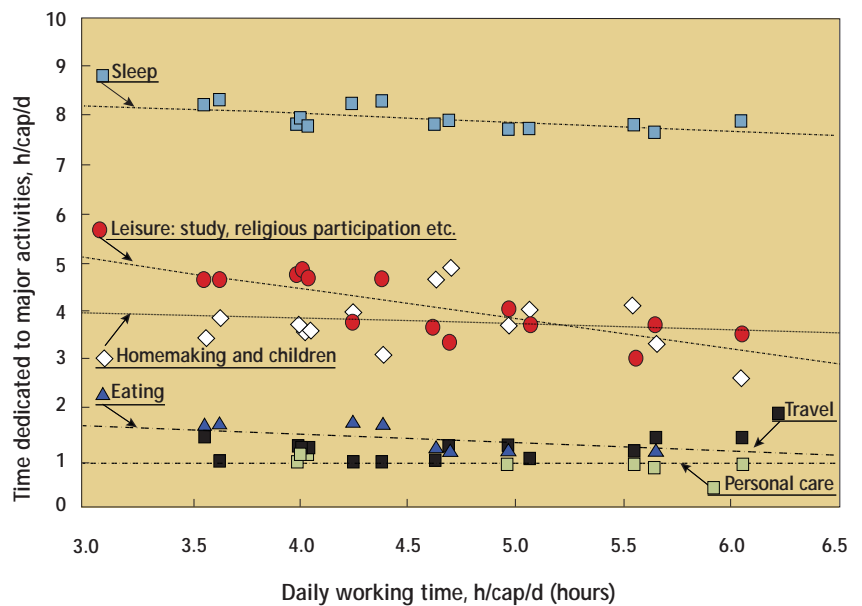


Figure 8 (from Schafer, A. [17])
Time expenditure for major activities as a function of work time 1965/1966

of the TT may correspond to an instinct acquired by the cavemen: when mankind lived in caves, they were forced to balance the risk of leaving the cave with the opportunities provided by the outside world. Mokhtarian [3] has found that the third component of the utility of travel (the one referred on the intrinsic value of the trip in itself) is connected to causes such as curiosity, pleasure of moving or desire of "getting away" and it is the basis of the existence of a certain desired TTB (Travel Time Budget), whose value can vary depending on education and socio-economic conditions.

The author [3] believes that the time that every man devotes to mobility each day is to be interpreted in part as a physiological response to the need for supporting oneself, typical of any moving creature (for example the search for food or, in the most evolved, house-work trip). However, since in the absence of any need, the man still manifests the need for mobility, it seems more relevant to interpret this quantity of time as the sum of two entities. The first could be named ATTE (Animal Travel Time Expenditure) and could correspond to the mobility that the "animal human being" needs for her/his existence. The second - HTTE (Human Time Travel Expenditure) - could correspond to the mobility required by each man as such, quite apart from the need related to survival.

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The demand for mobility (km) has increased with economic development

Although the average travel time per day is constant, this is not true for the space covered: it can vary considerably as shown by Figure 9 taken from Schafer [17].

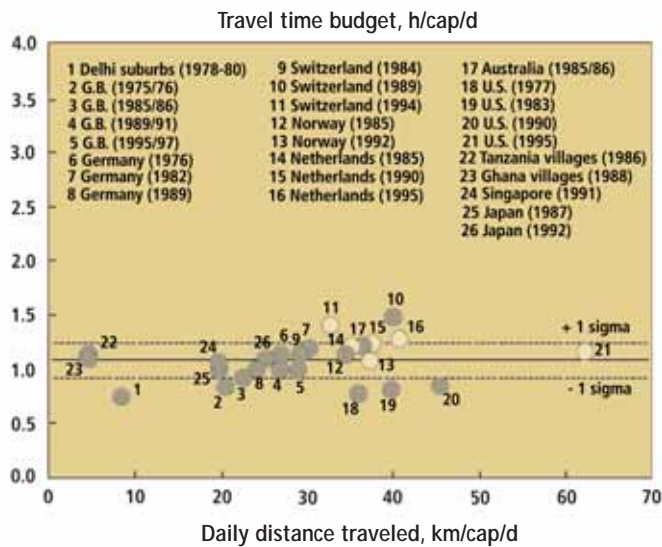


Figure 9 (from Schafer, A. [17])
Daily distance traveled, km/cap/d

To find out the main factor affecting travelled distance change is sufficient to consider Figure 10, also taken from Schafer [15]. The figure shows the correlation between the average km per year and the average income per person. Indeed based on this, it is fairly obvious that economic availability leads to cover longer distances.

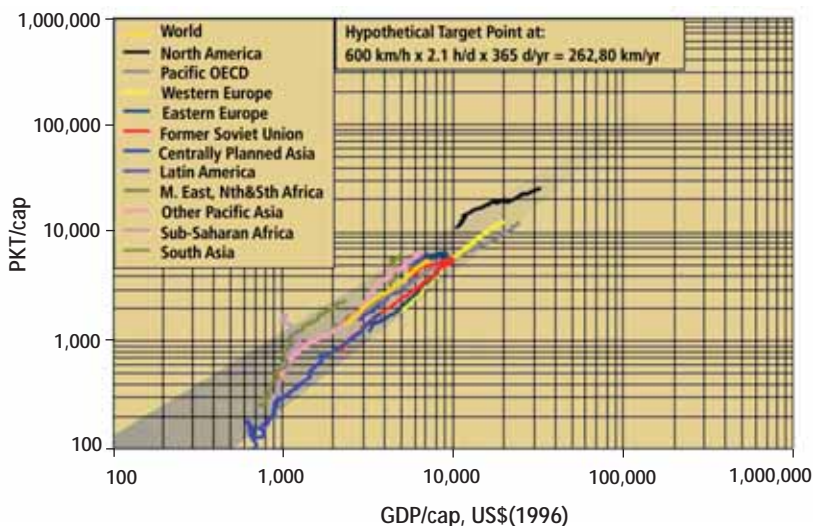


Figure 10 (from Schafer, A. [15])
Global mobility trends (1950-2000)

The speed of mobility has increased with economic development

If the average time that a person devotes to mobility is constant and the space increases with income, it follows that also speed of travel varies with income. Therefore, we have to expect that a greater economic availability entails a faster travelling and therefore causes using faster transport modes.

The confirmation of this hypothesis comes from the analysis of Figure 11. The figure shows the correlation between income and the trends of the percentage of travellers which choose public transport (bus and train - decreasing trend with increasing income), private car (bell-shaped trends) and high speed transport modes (high speed trains and planes - increasing trend with increasing income).

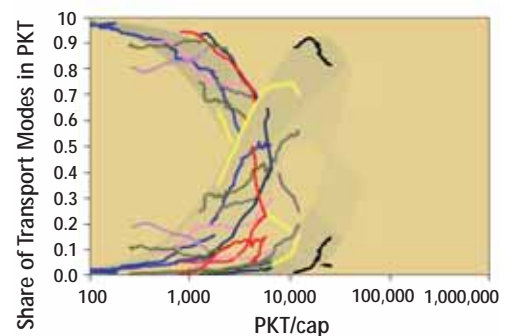


Figure 11 (from Schafer, A. [15])
Shift toward faster modes (1950-2000)

Actually, it seems that, with a larger income, people tend to “control” a more and more increasing part of territory. This behaviour leads to two effects:

- people tend to use individual means of transport to travel without limitation in space and time by others;
- to cover bigger distance in the same quantity of time, they use faster and faster systems.

But does this process, that seems to be evident and inexorable and that favours intercultural and commercial exchanges, not present some side-effects?

Probable future economic development leads to unsustainable mobility

Figure 10 indicates that average number of km travelled in one year is proportional to the average annual income.

So, if we all want globalization to lead to a rapid growth in income for all people of the world, it means that milliard of people in the future will access to faster and faster modes.

Figure 12 ([24]) shows that they will first abandon the non-motorized modes for collective motorized ones, and then will choose the individual modes respect to the collective ones. Finally, everybody will use high-speed transports, causing problems to management of territory and systems that, because of their complexity, cannot be imagined today.

This perspective could appear positive from a socioeconomic or equity point of view, but it isn't so if we consider the use of energy resources, the potential pollution derived and the quality of life in general.

Nowadays, in fact, motorized transport is responsible of a quarter of energy consumption (International Energy Agency) [25] and of CO₂ emissions (Figure 13). Several authors like Broccoli [26] Pacalaw and Sacolow [27] affirm that, if these trends are confirmed, warning levels could be rapidly reached in the future.

For these reasons, it's important and pressing to find new behavioural perspectives to completely invert existing trends, and so to introduce future transport systems into sustainable equilibrium.

Need for change: using the constancy of desired time of mobility to reduce travel speed

Let's consider two statements presented in the previous sections:

- The constant travel time law, that affirms average time daily spent for mobility is constant for different populations and historical periods, and independent on the mode of transport.
- The fact that it seems every person has inside the same quantity of mobility demand: who travels much more or much less, suffers.

If these assumptions are valid, as experience and some available statistics seem to confirm, we can try to change human behaviour to modify current trends.

If a person needs a daily travel time budget of 1.1hour, we have to persuade people to insert in this budget as much quantity of "positive" mobility (sustainable and non-motorized) as possible. So, time spent for the "negative" mobility will be only the residual one, still available in the total TTB. Its quantity would have to be the strictly the indispensable one, so that people

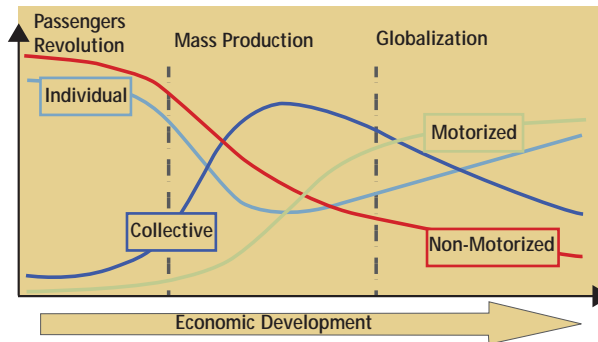


Figure 12 (from Rodrigue et al. [24])
Passengers mobility transition

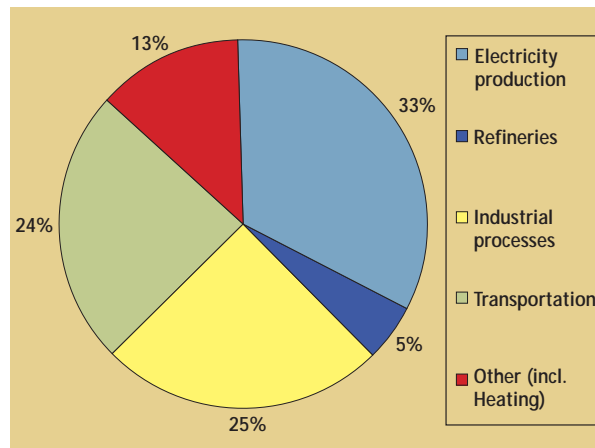


Figure 13
(from Hansen et al.,[29])
Global CO₂ Emissions

would not suffer the excess of mobility, reducing their life quality.

Action that intends to reduce directly the total daily TTB, indeed, will lack efficacy, because people will naturally tend to compensate for this reduction, as Hojer and Mattson [13] affirm.

In practice, considering our whole mobility to be constant and made up of two components, one "positive" and one "negative" from the point of view of sustainability, we have to support "positive" mobility to grow up if we want to reduce the "negative" one.

It will be necessary to persuade people to shift their own mobility demand towards slower transport modes - rationalizing, at the same time, the use of faster transport modes - in order to achieve this objective.

Slower modes, in fact, mainly respond to human nature (people for millions of years were pedestrians – Colonna et al. [28]).

To reach this goal, not only a large and shared promotional action is needed, but mainly favouring all the boundary conditions (infrastructural, planning, economic, etc.) that really encourage people to spend their "positive" mobility.

This behaviour, though connected with the original human nature, is actually contrasted by the identically human individual attitude to control wider parts of territory, increasing speed while spending the same time (Colonna [4], Marchetti [16]).

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Possible strategies to support the share of sustainable mobility

In the section below the author will try to individuate some of the potential strategies that can be promoted.

Some of them are easy to develop and requires little budget. Some others challenge ways of life considered, in the last decades, objectives to reach to increase social status and so well-rooted in the whole population. In this situation, the possible inversion of trend - that however appears necessary - could introduce big difficulties in obtaining people's consent, in particular of who are now gaining such a social position or have been having it for a few time.

In the following two paragraphs, some possible strategies have been listed under conventional categories to help readers. However this classification has to be considered absolutely flexible, since every action could have consequences in larger areas than suggested by the related category.

Reforms to favour the share of sustainable mobility: the road system

To begin, reforms related to infrastructures will be examined, starting from the urban ones which are the most used for "positive" non motorized mobility - therefore it will be necessary to encourage and make easier the use of sustainable modes on them. Then the extra-urban context will be analyzed, whose infrastructures need rationalization strategies. As to urban road system, the following actions could be possible:

- Definition of high quality standards for the project and the realization of urban roads and their pertinence (including aesthetic, functionality, road safety, services, protection from bad weather, opportunities, presence of intermodal connections, etc.).
- Bonus for families without private car.
- Integration of the traditional tasks of traffic warden with activities supporting pedestrian mobility (especially for children and elderly people).
- Additional taxes in more congested areas and increased parking price.
- Disincentives to use motor vehicle.

Other reforms also connected with the urban road system have been described in the paragraph concerning land use, since they could have a more extensive and spread impact.

About extra urban road system, we could list, for example:

- Speed limitation and control on free roads.
- Limitation of number of kilometres covered with the private car.
- Incentive for cars with few kilometres.
- Pricing proportional to speed.

Reforms to favour the share of sustainable mobility: land use

Land use affects directly people mobility and could significantly influence the modal choice and consequently travel speed. It's important promoting and implementing actions which support the share of sustainable mobility through land use. Below you can find only a list of possible strategies - as examples - that would need a better description. Among these:

- Displacement of private parking from the destinations.
- Distribution of activities so that family travels are compatible with pedestrian and cycling mode.
- Project, planning and realization of pedestrian and cycling networks.
- Organization and rationalization of public transit networks.
- Incentives for companies who realize parks and services for pedestrian or cycling mobility for their employers (e.g. between the parking spaces and the work site).
- Etc.

Freight transport and cost equilibrium

Some of the possible actions proposed are able to influence deeply economy, so they could find important oppositions in their implementation. This could happen, e.g., in freight sector in which, in the last years, after globalization, the consumption of unnecessary products, arriving from long distance, has been facilitated.

In order to limit this superfluous consumption, an additional fee could be imposed on a product when a minimum threshold of distance between the production and consumption site is exceeded. For some consumption goods, a Transport Impact Assessment could be introduced, a simple tool to compare global transport costs and benefits for the final users.

As to passenger sector, it's well known how public subsidies are significant in transit budgeting. This to favour people mobility

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and economic development.

However, in some developed economies, in which income has overcome particular threshold this practice should be progressively reduced (for high speed transportation in particular), so take price perceived by users towards a more physiological equilibrium with the real costs of services.

Reforms to favour the share of sustainable mobility and transport: the cultural education

Modern society is more and more influenced by communication processes and systems. If the existence of new behavioural principles – according to which the whole world population helps present and future generations – is demonstrated, it will be essential these ones to be acquired and spread, but overall responsibly participated. This have to be done in order to obtain spread consent, at first, and then a behavioural change, especially necessary if those principles imply the need to partially limit freedom in favour of common good.

It's necessary to involve cultural subjects in the process who are able to individuate and describe the common good, then sensible subjects that could provide a preliminary spread, finally politicians and institutions that could work with their instruments to implement these strategies. So, interventions will not be imposed to population, but on the contrary, will be fully participated and supported by a large part of it; thanks to a harmonic and productive process of acquirement of consent. The whole chain of education has to be involved in the final objective, using all available instruments. The educative role of School and University could be decisive.

Conclusions

Nowadays rapid social and behavioural changes, occurring all over the world, have challenged sustainability of transport infrastructures. Their actual utility for present and future humanity has been contradicted for the first time after several millennia; that is to say after when, with the animal taming and the discovery of the wheel, mobility and transport

have developed as technological systems advantaging humankind.

The consolidated equivalence between development and transport infrastructures has changed into a worrying inequality between sustainability and transportation, arising some doubts which impose the ethic and cultural obligation to deeply reconsider the whole matter. The analysis of collected statistical data and the evidence of human behaviour led to think that the whole process is probably significantly regulated by the following principles:

- For people, the desired average time devoted to mobility is little more than an hour;
- Average travelled distance increase with income;
- One of the consequences of the economic development is the use of transport mode faster and faster;
- If this process will continue indefinitely without new technology reducing significantly the emissions (technologies that now appear far from being developed), it could drive to consequences not acceptable from the point of view of sustainability;
- Considering that human beings have always used non-motorized mobility – congenial to them – and that the average travel time expenditure is little more than an hour, it's possible to imagine how to invert this trend. In fact, the inversion will be possible only if people become aware of the necessity to devote more time to daily non-motorized mobility. This, in fact, would compensate a probable reduction of high speed and motorized mobility, since it would be devoted to this less residual time;
- Such a behavioural change – however advantaging health and wellness and probably reducing effects of road accident – is mainly perceived and pressing in developed society;
- It is possible to implement strategies in the fields of transport infrastructures, land use, economy and cultural education, according to a synergistic process among all institutional and human components that cares about wellness and life quality of present and future generation. ■

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