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ABSTRACT

Activity patterns within the built-up environment are sustained by the transport system. Both transport system and built-up environment are in their turn sustained by the natural environment. The mass consumption system, in which we live is all the time diminishing the capacity of the natural environment to sustain us. The negative development can already be seen across the Europe.

In this paper the transport system is analyzed according to the system-keeping principles of evolution, which are variety, closed circles (re-cycling), maximum efficiency in using energy and resources, self-regulation, and regionalisation.

When comparing the modern transport system with the five system-keeping principles of the ecosystem, we can observe an increasing discrepancy between the rules with which life goes about solving problems and the technical and economic solutions used in the transport system.

Two factors can be derived from this analysis as the main causes for the discrepancy: The **quantity** and the **speed** of traffic. Both factors are developing in a synergetic process which takes no account of the ecosystem. At least in the short run, there are not enough feedbacks for the self-regulation of the transport system to keep the development within the bounds of the environment needed for the dignity of human life.

The effortless and unbridled use of energy in the existing transport system indicates that no effective control system is functioning. An open question is whether our insight is good enough and our ability to learn is faster than the damaging process brought on by uncontrolled development?

PREFACE

This study has been carried out in cooperation between the Institute of Traffic Engineering at the Technical University of Vienna and the Road and Traffic Laboratory at The Technical Research Centre of Finland. A major part of the work was undertaken by Hermann Knoflacher during his visit to Finland in summer 1989. Veli Himanen has written the introduction and edited the report.

The language of this report has been corrected by Wordcraft Ky.

CONTENTS

1 INTRODUCTION

Activity patterns within the built-up environment are sustained by the transport system. Both transport system and built-up environment are in their turn sustained by the natural environment (Fig. 1). The mass consumption system in which we live is all the time diminishing the capacity of the natural environment to sustain us. The negative development can already be seen across Europe /1/.

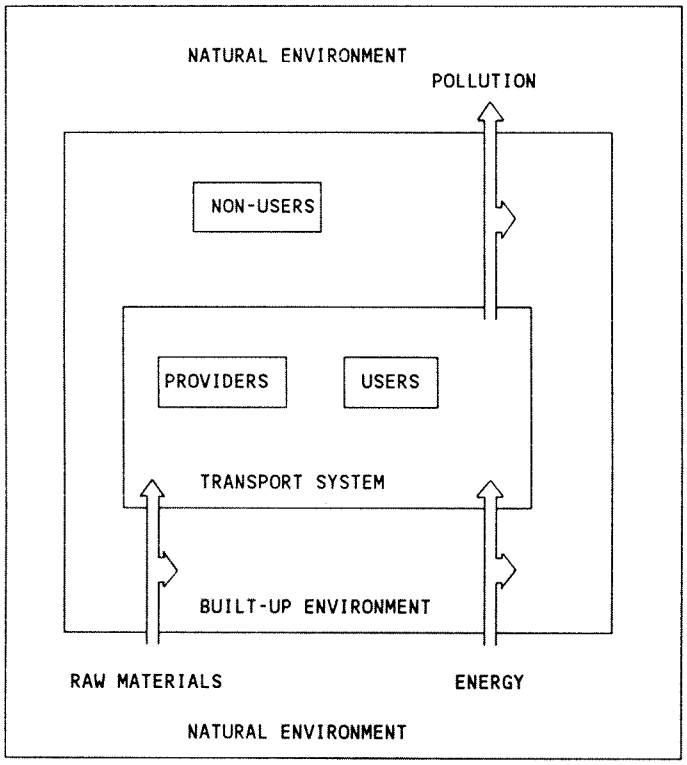

Figure 1. The transportation system and built-up environment are sustained by the natural environment.

Human life is dependent on the uninterrupted operation of the natural ecosystems. To be able to derive lasting benefits from nature we must take care of it.

Environmental systems do not react immediately to the effects of human activities, since they can resist for a long time by stabilizing feedbacks, but they cannot compensate for environmental disorders indefinitely. Only a few species of plants and animals have been studied thus far, but all of them are important for human life. The different forms of life are connec-

ted and interdependent. All have the right to life, regardless of whether they are currently deemed useful for mankind or not.

Each generation is not the owner of the globe, but merely its custodian, and has therefore the duty to leave to succeeding generations an environment and resources offering at least the same conditions of life as they have enjoyed. Since the future generations are not in a position to negotiate this contract, we are responsible to keep open the options for them.

Owing to the complexity of the biosphere, human activities as well as human neglect can have both intentional and unintentional effects of great consequence. An extended responsibility is therefore necessary. The use of technology and scientific research results must be based on insight, caution, and responsibility.

When planning transport systems, we use economic calculation methods tailored to transport planning. Economic appraisal theory was adopted in transport planning around the year 1960 /2/. One of the basic economic issues nowadays is the relationship between economic growth and the environment /3/. The difficulties of integrating environmental issues into traditional economic policy-making, conventionally geared to maximizing GNP, has been pointed out already in 1977 /4/.

Economics as a science is according to Giarini /5/ related to the process of industrialization that started in Europe more than two hundred years ago. In the post-industrial society many economic models, including some of those affecting transport planning, may have lost their relevance. Among the particularly awkward questions are those related to wastes and the use of so-called "free utilities", e.g. air and water. Scientific problems of economics, coupled with the simple methods used in the evaluation of transport infrastructure /6/, make the execution of transport policy rather irrelevant.

In the following study, system-keeping principles of the ecosystem are described and the transport system is analyzed according to them.

2 SYSTEM-KEEPING PRINCIPLES IN THE ECOSPHERE

The evolution in the ecosphere has developed in accordance with system-keeping principles /7/:

Variety means harmonious, interactive complexity, which stabilizes the system.

Closed circles (recycling), where each item of refuse is completely used as a basis of existence for other organisms.

Maximum efficiency in using energy and resources.

Self-regulation, when parts of the system tending to uncontrolled (exponential) growth are checked by stabilizing feedbacks.

Regionalization, where the global ecological equilibrium is the result of interactions between systems which are optimized according to local conditions.

3 VARIETY INSIDE HARMONY AND INTERACTIVE COMPLEXITY

At first sight, it would appear that technical development has increased the degree of variety in the transport system. Beside non-motorized road users, we have all kinds of motorcycles, cars, trucks, buses, and special vehicles.

Variety in an ecosystem is dependent on harmony, cooperative or interactive complexity, and stability.

Over thousands of years, harmony has been developed between pedestrians by social rules and cultural behaviour patterns.

China, Albania, and to a certain extent Japan have been able to reach a measure of harmony and interactive complexity between cyclists and pedestrians.

Many countries make attempts in this direction with a greater or lesser degree of success when they mix both these road users on sidewalks or in pedestrian zones /8/.

From pedestrians, the bicycle represented only a minor change in energy demand, speed, and increased mass. However, this simple step created problems we have not been able to solve in the space of 200 years. The expedients are still laws and not rules, enforcement is employed instead of sensible discipline, and infrastructural measures are needed for separating these two groups /9, 10, 11/.

The increase in the variety caused by bicycles was still in harmony with the environment, which did not have to be greatly altered to accommodate these vehicles. Also the pollution produced by the manufacture of bicycles was not a great threat.

The steam locomotive on its rails - the iron horse - changed the scene 50 years later. At this point people became aware of air pollution and noise. They were fearful of the negative effects on animals, plants, and human beings /12, p.10/. The production processes of the industries underwent tremendous changes, as did the growth-patterns of many cities. Industrialization, with its concentration of man and capital, got under way /13, pp. 532 - 541/.

Railways increased variety but disturbed harmony as never before. This was the price for the increasing complexity. Interaction with this new element in the transport system was restricted to stations only.

The higher speeds involved made this mode of transport dangerous for everybody outside those places allowing controlled access. Numerous instructions for railway employees and users of this mode were necessary for safety reasons. We saw the beginnings of the control of human life by a technical system /14, 15/.

The price for this increase of complexity was paid in noise, a decline in the quality of life for an increasingly large section of the population, isolation and separation by railway tracks, accidents, timetables, detours, and waiting times for all other forms of transport when they came into contact with the railway.

We find an increasing contradiction between this system-keeping principle of evolution and the effects of railways. However, the impact on the envi-

ronment was not as bad as had been feared, and with the use of electricity some of the adverse effects have diminished.

The sensitivity of people towards for technically-induced restrictions of their life has decreased in the last 150 years, to the point where railways are nowadays considered as the mode of transport most compatible with the environment. This change has come about mainly through the comparisons made with the increasing vehicle traffic on the roads.

Cars, developed some 50 years after the railway, were a further contribution to the variety of the transport system. The first prototypes were not taken very seriously, but the increasing speed, another factor bearing on the variety, made it necessary to introduce more and more regulations for manufacturers, drivers, and all other road users /16/.

For pedestrians and cyclists, groups representing the overwhelming mass of trips travelled among road users, these regulations brought additional restrictions of free movement /17/. International orchestration of rules became necessary since the increasing speed lengthened the trips taken, carrying them across national borders.

Vehicle traffic is not interactive with other road users, nor even with itself, without strict regulations and additional enforcement.

We find here the greatest contradiction to the principles of natural evolution if we consider only the transport system. The number of accidents reached a new plane, and what is most astonishing, this cost has become commonly accepted. Accidents are an indicator for conflicts and the conflicts in turn indicate a lack of harmony and ability to cooperate smoothly.

The increasing use of cars brings out yet another aspect of variety, the limited capacity of the environment. What began with regulations has now lead to dirigism /18, pp. 78 - 82/, and to a certain extent to terrorism against the environment /19, pp. 116 - 117/. The inability to use high speeds in the natural environment made it necessary to adjust the environment, to simplify it. Roads with a smooth surface had to be built and reduced to their most fundamental form - a network of motorways. The motorways represent the greatest contradiction not only to nature but also to the variety of road users. Owing to the high speeds involved, the variety must somehow be limited - and separation is the result. Road planning guidelines take care of "harmony by separation", and traffic laws see to "cooperation" in the complex traffic world /20/. Traffic lights, curb-

stones, and parking regulations have replaced the former complex interplay among road users. The high speeds have made them necessary.

The road, in former times a place of life in the settlements, was reduced to performing a simple transport function, from A to B.

Vehicle traffic has added variety in the transport system, and at the same time it has increased disharmony in the transport system itself, in the environment, and also among road users.

Vehicle traffic has also had a tendency to actually diminish variety. The pre-motorized transport system had developed, depending on local conditions, a large number of different vehicles and had used various kinds of animals for transport purposes. During the summer months various carts, carriages, and coaches were used according to the local conditions, being replaced during the winter sleds and sleighs.

In waterborne transport we saw the development of an assortment of vessels and floating methods using wind energy and gravity.

Besides human power, wind, and gravity, man made use of horses, oxen, cows, donkeys, camels, and dogs.

This variety was the result of two factors: the available resources and the best way to use the local conditions without changing them unduly.

What today happens is the opposite: the environment has to be adapted to the car wherever it appears.

4 CLOSED CIRCULATION WITH COMPLETE RECYCLING OF ALL WASTE

The natural recycling process depends on materials, time, quantity (throughput), and some external factors such as temperature, humidity, and the like.

Pedestrians, horses, wood, and natural products are part of the natural system, which has developed a perfect recycling process for them. The amount of iron and steel, rubber, glass, and other materials for manufac-

turing bicycles and the lifetime maintenance of them produce only a limited quantity of waste. Most parts can also be recycled.

The railway vehicles and tracks can be recycled to a great extent. The natural lifetime of most parts of the system is/was rather long and the railway administrations have established some kinds of recycling already. At this stage the transport system itself was not the problem. The ability to transport huge amounts of goods and people by means of the railway system fostered the industrial growth that caused recycling problems for its waste (unsolved even today). Not only the toxic effects of wastes became an issue, but also the sheer quantity of waste appeared to be an insurmountable problem for recycling /21, pp. 124 - 137/. Electricity generating stations based on coal, nuclear energy, oil or gas are a problem themselves which can only be touched on in this context.

The car itself as an isolated event creates only minor recycling problems. What makes it so problematic is the mass production introduced by Henry Ford /22, p. 67/. The manufacturing and use of cars release wastes to the atmosphere and to the environment which remain there almost indefinitely and cause damage.

The toxic effects of pollution and the huge quantity of wastes generated are the major problems for the natural environment caused by the transport system. The demand for space must also be considered, since the space has to be taken from the natural environment. Even if the road space accounts, in relative terms, for only a small percentage of the total area, it may still have untold influence, since we do not know just how stable is the ecosphere /23/. The increase of carbon dioxide in the atmosphere indicates that there is not much give left in the system, otherwise the ecosphere would have absorbed it /24/.

The use of salt in winter road maintenance, or the release of lead and other toxic elements into the ground and the ground water have effects as yet not studied with any degree of thoroughness /24/.

The increasing mass consumption and the release of damaging products into the environment in a quantity as never before have created sick and dying forests, the "greenhouse effect" of global warming, and polluted waters. This reveals clearly that the natural recycling process is overburdened.

Comparing the attributes of the natural recycling process with the existing transport system we can see an increasing contradiction mainly created and induced by mass production. Many parts of the transport system are not recycled and are therefore stored in the atmosphere or in the soil and water.

5 EFFICIENCY IN USING RESOURCES AND ENERGY

Life itself is characterized by efficiency in using resources and energy. Human society is currently using resources and energy for mass consumption, where efficiency is a means to more production and more consumption.

Efficiency in our context means use of material - which is itself a special kind of energy and information - and energy in a way that our evolution has developed: solutions which minimize input and maximize output under the prevailing conditions of the system. Man himself is the result of this process. His behaviour tends in the same direction as far as his own energy is concerned, physical or intellectual.

Walking requires more energy than cycling for the same distance. Cycling is therefore an improvement in efficiency /25/. Using railways or public transport in a sitting position can reduce the use of personal energy. However, the overall amount of energy in the system increases appreciably, even if we do not take into account the energy needed for all the prior processes of establishing and maintaining the public transport system.

The reckless use of natural energy resources (coal, gas, and oil) in great quantities seems to be cheap in "economic terms". These resources have been accumulated over millions of years by organisms. The consumption of them in a short period is in absolute contradiction to the basic rules of our ecosystem. Economics related to the industrialization period thus uses totally different rules relative to those of the ecosystem. However, because the mass consumption society is ultimately sustained by the natural environment, the rules of the ecosystem are the ones which will count in the end.

With the car, the situation becomes even worse. The energy demand increases roughly tenfold compared to walking /26/, and would be much

greater if we add the amount of energy which is stored in the carriageways /27/ and used for maintenance, policing, hospitals, repair workshops, etc.

Road transport also captures increasing amounts of the landscape /28/, consumes scarce space in cities and villages, and causes adverse effects in aesthetic terms.

Instead of increasing efficiency, we find the opposite effects in the system, although we experience the feeling of maximal efficiency when using the car. The modern transport system is characterized by wasteful use of energy and all kind of resources. It can be shown that energy demand increases with the third power of speed, taking into account the system effects. For this calculation the traffic generators and their changing positions have to be included in the defined system.

6 SELF-REGULATION AS A STABILIZING FEEDBACK

Self-regulation is necessary to stabilize systems when they are disturbed. Nature has developed stabilizing feedbacks for cases of escalating development. Exponential growth leads to system-endangering instabilities and therefore it is usually controlled by stabilizing feedbacks. Cancer is an example where stabilizing feedbacks are out of order. Next we consider the effects various transport modes have on settlement patterns and the environment.

Pedestrians use very limited energy and speed. Moreover, here we have a practice as old as mankind. Pedestrians have stabilized human settlements for thousands of years. Pedestrians are the stabilizing factor in the transport system /30/.

Cyclists have not destabilized any system, as far as there are data available. They are also self-stabilizing in the same way as pedestrians. Although they are useful for transport of people and goods, they cannot destabilize settlement structures, existing equilibriums, etc. Bicycles are more used as supplements to the pedestrians. They did not need additional carriageways and are compatible with pedestrians in the countries where they have become the main transport mode.

The railways were the first mode using "artificial energy". The new speed dimension available with this form of transport, together with its great

carrying capacity, had changed the pattern of production dramatically during the 19th century /29/. The growth of the railway system was, however, limited for various reasons obviously within the critical borders of the ecosystem. The railways did not destabilize the basic elements of human life in a broad sense, although they destabilized production and society patterns. The pre-railway society is not the same as the post-railway society. The effects of the railways were more regional and national than global. The railways still constitute a well-controlled system in itself which has controlled access and predetermined speed. It has shrugged off some former adverse effects through technical innovations. With modern technology, the remaining negative effects could further be reduced. Internal and external feedbacks guarantee the stability of railway systems.

Cars have altered settlement patterns by changing accessibility. Cities, villages, agriculture, travel behaviour etc., have all changed since cars became a significant mode of transport. The destabilizing process is still developing and is supported by different measures. All these measures tend to increase the speed.

The so-called "level of service" used in traffic engineering is a good example of these efforts to keep the speed at a certain level /31/. In the field of mechanical engineering the tendency to increase the speeds of the vehicles still exists /32/. The serious problem arising from this development is the worldwide increasing damage to the basis of our life, which indicates that self-regulatory processes are declining /33, pp. 60 - 65/. These effects are only partly created by the transport system itself, but its contribution is not negligible and in some countries it might be the greatest factor destabilizing the environment as a whole.

The increasing and specific use of external energy for obtaining greater speeds in the prevailing transport system has destabilizing effects on settlements and the environment, both at the local and global levels. Increasing instabilities which might become endangering are caused not so much by the car itself, but by its mass production and the speeds used. The adverse effects observed in the environment indicate a transport system without effective stabilizing feedbacks.

7 REGIONALIZATION

The global equilibrium of the ecosystem is the result of the optimal cooperation of locally adapted systems. Local adaptation is the result of various conditions and restrictions and it is one of the basic elements for different solutions (for the same problem) that we find in the flora and fauna.

The transport system during the pre-industrial era had developed a great variety of local optimal solutions for transport along the roads and waterways during all seasons. The local systems were connected with each other at a high level of logistics. Local energy resources were used in an optimal way, together with local know-how. The economic welfare of many cities in the Alps was based on this kind of transport /34/.

With the introduction of railways, regional solutions were also tried. There were different track widths, distinctive locomotives, and various solutions to build railway tracks on the mountains. Some of these differences nowadays cause problems, given the increasing uniformity needed for higher speeds. The visible effect of the regional optimization is the landscape with well adapted tracks. With increasing speed, regions got closer to one another but the station as the point of controlled access still remained as a synonym or a symbol for the region.

The "regionalization" was promoted by the railways by industrial development of some areas in parallel with the loss of industries in others. But this advance was already allied with the diminishing of local optimization. It is worthwhile to relocate some production from places of lesser efficiency to better sites, but not to any great extent. It is interesting to note that, after the collapse in the steel industries, some parts of the industries in certain traditional steel areas are still profitable if they are suitably specialized.

From today's perspective we can see that the railways have brought a major contribution to the cooperation of regions, but have had some adverse effects on regional branches of industries. Usually the railway planning takes account of the regional conditions, and is doing so even now as can be seen for example in Switzerland /35/.

The car developed in Europe and introduced as a mass product in the USA was first used as a regional mode of transport because of the low speed obtained. During the first decades of this century car traffic was also restricted by the poor road network and the lack of energy supplies.

The increased speed with the overall accessibility provided by an extended road network destroyed "regional borders" within two decades. Today we find the same products, which may imitate regional specialities, in shopping centers around the world. There is less and less scope for distinguishing and recognizing local abilities and specialities. It also becomes more difficult to distinguish "copies" from regional originals. Air traffic contributes to this trend by business and holiday trips. To prevent self-regulatory effects, all obstacles hindering this development are cleared away without care for the environment and the people living there.

Regionalization also means different conditions in climate, culture, fruits, etc. Since everything is available all the time all over the world, we can no more speak about regional differences. Wherever we go, the same problems can also be seen in the transport system itself. The transport system, once a tool for discoveries, is now used in a way that there will soon be nothing worthwhile to discover. Mass use of car and air transport destroys its own basis, to which also regional differences belong.

8 CONCLUSIONS

When comparing the modern transport system with the five system-keeping principles of the ecosystem, we can observe an increasing discrepancy between the rules with which life goes about solving problems and the technical and economic solutions used in the transport system.

Two factors can be derived from this analysis as the main causes for the discrepancy: the quantity and the speed of traffic. Both factors are developing in a synergetic process which takes no account of the ecosystem. At least in the short run, there are not enough feedbacks for the self-regulation of the transport system to keep the development within the bounds of the environment needed for the dignity of human life.

The effortless and unbridled use of energy in the existing transport system indicates that no effective control system is functioning. An open question is whether our insight is good enough and our ability to learn is faster than the damaging process brought on by uncontrolled development?

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