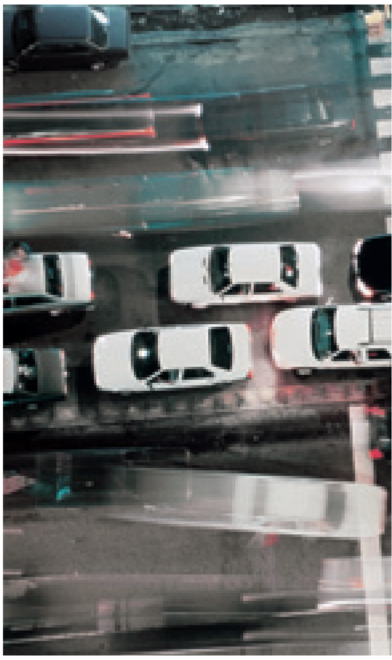
Does our mobile society need to rethink its attitude to stay mobile?

“We cannot control everything top-down”

Interview ▪ Professor Dr. Dirk Helbing, Full Professor of Sociology at the Swiss Federal Institute of Technology in Zurich (ETH) and former traffic scientist at the TU Dresden, speaks about the phenomenon of self-organization in complex systems and about the possibilities of using modern sociological insights for optimizing road traffic.

Intersections in Tokyo and Buenos Aires: "The movement of crowds of people is largely determined by these same crowds"



Professor Helbing, while some of your colleagues are rather pessimistic in regard to the future of our automobile society, you are generally counted among the group of more optimistic researchers. Where does this confidence come from?
Of course, we cannot ignore the challenges that we are facing, but I think that, thanks to many promising innovations, the chances clearly outweigh the challenges. The insights that modern sociology and traffic research have already delivered about the typical and sometimes unexpected processes in complex systems can go a long way in optimizing road traffic and meeting our climate protection goals without limiting mobility. But if we truly want this knowledge to help us on, we must be prepared to adopt a different way of thinking. First and foremost we need to do away with our preference for controlling everything from the top down. We must not "force" complex systems such as society, economy or road traffic by drastic interventions, but support and promote their self-organizational powers through appropriate measures and efficient technologies. Then we will in fact have a realistic chance of improving traffic flow in the near future and cutting down on traffic-induced environmental pollution at the same time. Up to now we are still far from fully using this improvement potential, which is certainly huge in total.

As a trained physicist and mathematician, you worked on econometric topics and traffic modeling at the Technical University of Dresden and now you are teaching sociology at the ETH Zurich. Does this cross-disciplinary experience help you understand the systemic interrelations and processes that are behind the traffic events on our roads?
For sure. Owing to its many facets, understanding traffic requires specific know-how in several areas: natural sciences, for example, offer the best tools and procedures for analyzing problems, and econometry is useful for model evaluation and calibration, while engineering know-how is needed for the development of new solution approaches and sociology provides the necessary insights into human behavior. Road traffic works basically like any other complex system in the scope of which numerous people are interacting with each other. The behavior of crowds of people is largely determined by these same crowds. For this reason, such systems seem very stable and take long to respond to attempts to influence them from the outside. But all of a sudden, the tipping point is reached and everything changes abruptly. And the actual effect achieved at that point seems disproportionate to any immediate cause.

Could you give us an example?
Let's look at the behavior of car buyers in the face of climate change and the last fuel price shock: for years it looked as if car drivers in general firmly sticked to their habits in spite of everything. The change in attitude was long to come, but when it did, it came with a vengeance.

How does this apply to road traffic and what does the self-organization of this special system look like?
In case of high traffic density, the system tends to collapse, and this according to a quite unpleasant pattern, because such a collapse further reduces the effective capacity of the road network concerned. Thus, at the very moment when we'd urgently need higher road capacity, it suddenly shrinks even further. And the harder we try to maximize the performance of our traffic network, the bigger the problem in case of a break-down.

“Up to now we tried to steer traffic like one steers a ship – but things are not that easy”

This sounds, to use an unscientific expression, like a vicious circle from which we have hardly any chance to escape.
True, but mainly because for many years our efforts were largely restricted to only one single solution approach. We wanted to steer traffic like one steers a ship, with the captain as the central decision maker. But that’s not how things work with complex systems, where interventions from the outside usually also trigger unwanted side effects caused by so-called feedback loops. If you respond to the unsatisfactory result of an intervention by stepping up the intensity of the very same measure, you can hardly expect to achieve satisfactory results. Moreover, such interventions, especially attempts at central control, make the system very sensitive to unexpected changes in conditions because it loses its natural ability to adapt, an ability that mainly lives on the heterogeneous and largely autonomous behavior of the people involved. The current financial crisis is an impressive example for this mechanism: the evolution of a local fire into a global blaze was not only fuelled by the financial system’s manifold intercontinental ties, but also by the efforts at global standardization of the markets through international regulations such as Basel II.

“Complex systems seem stable for a long time – until the tipping point is suddenly reached”

This sounds quite logical, but what would be an alternative approach?
I think that, as a basic principle, we must always try to think “with” the system, and not to work against its natural mechanisms. In most cases, working “against” the system means forcing it in a certain direction, which is nearly always counterproductive in the end and wastes valuable resources, to boot. On the bottom line, our objective should be to strengthen the decentral mechanisms in a targeted way, fostering the road traffic system’s self-organizational power and hence its flexibility and robustness. In this respect, I stick with the ideas of Adam Smith, the founder of modern economics: according to the principle of the Invisible Hand, everyone involved should be allowed to do what they do best because the combination of a multitude of optimal individual solutions is the basis for a very flexible and robust »

Rail bridge in Dresden: "The

Personal background
Professor Dr. Dirk Helbing, 44, is Full Professor of Sociology at the Swiss Federal Institute of Technology Zurich (ETH) since June 2007. His scientific activities center mainly on the modeling and simulation of social structures and processes, especially on the interaction of people in space and time. Areas of research are for example collective decision making processes, group dynamics, the behavior of crowds, and the propagation and management of crises. Moreover, he works as coordinator for a large-scale Daimler-Benz Foundation project on biologically inspired logistics concepts. From 2000 to 2007, Helbing headed the Institute of Transport and Economics of the Technical University (TU) Dresden, where he was also Full Professor for Traffic Modeling and Econometrics. In December 1996 he qualified as professor of theoretical physics at the University of Stuttgart. His professorial dissertation focused on physical traffic flow modeling.

system. On the other hand, of course, sociology teaches us that egotistic behavior does not necessarily lead to the optimum result for the overall system. Self-organization can "miraculously" bring about spontaneous coordination and cooperation, but under certain, generally extreme circumstances also a catastrophic collapse.

"Ideally it's not the traffic lights that control the traffic flows, but exactly the other way round"

But how can we apply such insights towards optimizing traffic systems – for example for traffic light switching control?
First let's take a look at two extreme approaches to control, just to get a clearer picture of the basic problem. On the one hand there is the standard solution, that is the good old periodic switching control plan optimized on the basis of averages won from historic traffic data. On the other hand, we have a strictly local, adaptive control concept, which is restricted to an individual traffic light installation, but in return adapts in real time to the actual, current traffic situation. Today we are aware that, unfortunately, neither of these concepts works really well. The first is too inflexible because it cannot respond to changes in the traffic situation; and the second is unsatisfactory because it completely disregards the traffic situation in the surrounding traffic network. However, we have been able to develop a new procedure using these two individually largely ineffective strategies simultaneously so that optimum traffic control can be achieved by combining the advantages of local flexibility with the benefits of coordination between neighboring intersections. On this basis we can achieve the ideal case where it's not the traffic light control that forces the traffic flow to follow a certain pattern, but where the traffic flow determines the traffic light switching pattern. In complex systems, this kind of self-organization is often the most successful principle.

Ultimately this takes us to the field of adaptive network control, doesn't it?
Correct. In this respect, we could actually go one step further than the innovative procedures already in existence today. I think that the individual local control system has no need to know about the over-

coupling of transport modes can be easily simulated”

Traffic lights in Berlin: “Adaptive control systems promote self-organization”

all traffic situation in the entire network just to ensure effective local coordination. Data on the current traffic situation at the nearest intersection constitute a quite adequate basis for taking local real-time decisions that will be beneficial for the overall traffic situation.

Trade media quoted you with the claim that this combined approach would be sufficient to enhance traffic flow by up to 95 percent ...
I have read that statement, too – but this number is just an exaggeration by the media. The actually achievable increase in efficiency will be lower than that, of course, but still quite substantial. Our study of an urban area featuring several “green waves” revealed a reduction of waiting times by 36 percent for pedestrians, by 9 percent for motorized vehicles and by a much as 56 percent for public transport. In other scenarios, the improvements achievable for road traffic may even be higher than that.

Where and how did you measure these values?
In the scope of a pilot project, we used a computer simulation for an extremely difficult network section featuring numerous tram and bus lines in the city center of Dresden. Since the traffic authorities made real-time traffic and control data available for this project, our results are certainly sustainable.

“In modern traffic planning, computer simulations are playing an ever more important role”

Would you say that today computer simulations do already have a validity similar to that of real test drives?
Definitely, at least as long as the quality of the tools used and the underlying data base is correspondingly high. The good thing about simulations is that they provide an unbeatably simple and above all cost-efficient method of testing a very wide variety of scenarios, especially where different traffic modes are to be interconnected. This is why in modern traffic planning, computer simulations are playing an ever more important role.

Your endorsement of the self-organizational forces of traffic goes far beyond the area of traffic light control. »

Traffic control center in Düsseldorf: “We should always think with the system”

Congestion warning on the A99 motorway: “Road pricing must not penalize mobility”

In what other areas could we achieve positive effects through the targeted use of this phenomenon?
An especially important field of innovation is doubtless the so-called Cooperative Driving, for example using Car2Car communication. This area offers helpful options for supporting the self-control mechanisms of the traffic system. In a first step, it is crucial to choose the right interaction mechanisms: in exactly which way must a car respond to the actions of the preceding car in order to counteract the system’s trend to destabilization in case of high traffic load? In the scope of various federally-funded research projects we have been supporting VW Group in investigating the fundamental principles of cooperative systems and developing related products. In contrast to the driver assistance systems currently used, which mainly serve to increase driving convenience and safety, the focus of these applications is on stabilizing the flow of traffic and improving road capacity.

“The development of cooperative systems is more important than building additional roads”

What kind of applications are you thinking of?
Cars are to be equipped with radio sensors that detect each car’s immediate surrounding and the prevailing traffic situation. If, on top of that, the vehicles are given the capability of exchanging this information with minimum delay, we will be able to optimally adjust decisive factors such as vehicle distance and speed in critical road sections where tailbacks tend to form more easily, for example roadworks and access ramps.

How many vehicles will have to be equipped with such little electronic helpers in order to achieve measurable improvements?
Our research revealed that about five percent of vehicles would have to be fitted with such equipment to make a noticeable difference. With 20 to 40 percent we’d already see a huge improvement, and above 50 percent would come close to the optimum. Above that, the added effects would be negligible.

This means that such an approach could get traffic on our roads to move faster and at lower costs than with the construction of additional roads?
It certainly looks like that. On some road sections it may still be reasonable to offer the road users more lanes, but I think that priority should essentially be given to the speedy further development of systems that make cooperative driving possible – in particular in view of traffic-related environmental pollution, which can be significantly reduced through

Following in Einstein's tracks

ETH Zurich ▪ The Swiss Federal Institute of Technology Zurich is among Europe's most renowned universities of technical-scientific orientation. Since its foundation in 1855, as many as 21 Nobel Laureates have been connected with the ETH – for example Albert Einstein and Wilhelm Conrad Roentgen.

ETH Zurich is managed and funded to a large extent by the Swiss Federal Government, just as the ETH Berne. The university is the study, research and work place of more than 18,000 people from 80 nations. About 370 professors in 16 departments carry out research that is highly valued worldwide. They teach mainly in engineering sciences, mathematics and natural sciences, but also in the area of the humanities, social and political sciences, of which also the chair held by Professor Dr. Dirk Helbing is a part. In addition, the Institute of Transport Planning and Systems, part of the Department of Civil, Environmental and Geomatic Engineering, does research in transport technology, especially project planning, operation, maintenance and upkeep of traffic infrastructure, as well as in traffic planning and its interrelations with regional planning, the environment, society and economy.

more smoothly flowing traffic, as we all know. By the way, in times as these, with automotive companies and the semiconductor industry struggling for their survival, the targeted promotion of such automated driving systems could generate important economic momentum. And speaking of the economy, modern technological options such as Car2Infrastructure communication could also make a substantial contribution to the funding of general mobility – through public-private partnerships.

Could you put this technology to use also in road pricing?
On principle we could, as long as we take account of the drivers' interests. For this purpose the road pricing models used today would have to be developed into systems that don't penalize mobility, but optimally distribute the traffic volume over the availably network. Mobility options optimized for the overall system could be distributed equitably among all road users, who could trade their respective share like a totally normal commodity. Such a system could be easily realized using the satellite-based toll collection technology already available today. Upon entering my destination into my onboard unit, I am assigned a specific route calculated in function of the current traffic situation. If I think this route is too slow, I can choose a faster one, for which I will have to pay correspondingly more. And this amount or a certain portion of it will then go to the driver who gives up his space on the faster route for me because right then he prefers the money over the time saved due to the shorter drive. This could be one highly efficient measure used to cultivate the self-organizational mechanisms of the complex system "traffic."

"It is possible to deploy a pricing system that serves the environment and the drivers alike"

On the technological level, this model seems absolutely realistic. But when will society be ready to adopt it?
This time may come much sooner than we think – if the system honors the interests and the privacy of the drivers, i. e. if it does not record who chose which route. Remember the trend that we talked about earlier: the car buyers' behavior in the face of all the discussion about climate change. For the longest time the thinking patterns didn't seem to evolve at all, but then, all of a sudden, everything changed. Whenever we try to catch a glimpse of the future, we must never forget that the visions of today are the realities of tomorrow.

Professor Helbing, thank you very much for the interview. «