TRANSPORT CHALLENGE IN 2020 – 2050

ECTRI POSITION PAPER

Research Needs in the field of Traffic Management

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Our vision

A future transportation system should strive to fulfil the following objectives come true:

- User-centric mobility
- Zero accidents and zero emissions
- Minimum space, time, energy & costs for transport

Introduction

ECTRI launched its Thematic Groups in September 2007 as a means to facilitate exchanges among its researchers interested in similar research fields and in order to promote joint initiatives and positions. The main objectives of these groups are to define research challenges of interest for supporting EC policies and programmes, to increase successful participation in EU projects and to provide a platform for networking and scientific exchanges. One of these groups is the Thematic Group on Traffic Management (TG-TM). The group consists of 21 experts from 17 Institutes and Universities representing 11 countries[1]. They represent the top European institutes in the field of modelling of road transport, analysis of traffic data, traffic management and traffic information, and also integration of IT technology in cooperative ITS (Intelligent Transport Systems). This paper aims to present the **research needs** as identified by the group in the field of traffic management for the horizon 2020-2050 to tackle the vision of **a transport system with is user-centric, with zero accidents and zeros emissions, and using a minimum space, time, energy and costs**.

Research Needs for a User-centric Mobility

A **shift from traffic flow management to management of individual movement** is deemed necessary towards a **user-centric mobility system**. Such a system should be able to advise its users in real-time of all/best available options to accomplish a journey from point A to point B, including a combination of various itineraries while integrating different modes and means of transport applying hierarchical control principles. User-centric mobility management should be able to consider different needs and preferences. To accomplish not only the individual traveler optimum but the system optimum, the mobility management system should collect, use and present in a friendly and catching way all necessary information in order to convince its users to act efficiently. The above require close user-infrastructure cooperation.

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AIT	Austrian Institute of Technology	AT
BASt	Federal Highway Research Institute	DE
CDV	Transport Research Institute	CZ
CENIT	Universitat Politècnica de Catalunya	ES
DEUSTO	University of Deusto	ES
DLR	German Aerospace Center	DE
FhG	Fraunhofer-Gesellschaft	DE
HIT	Hellenic Institute of Transport	GR
IFSTTAR	Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux	FR
TRL	Transport Research Laboratory	UK
TTI	Transport and Telecommunication Institute	LAT
TUC	Technical University of Crete	GR
UNEW	Newcastle University	UK
UNIZA	University of Zilina	SK
UVEG	University of Valencia	ES
VGTU	Vilnius Gediminas Technical University	LT
VTI	Swedish National Road and Transport Research Institute	SE

To test and assess such a management scheme before its deployment, reliable modelling tools are necessary:

First, modelling tools must be able to make **correct multimodal predictions**. This includes (i) the total **travel demand** (number of people and/or goods willing to travel from every origin to every destination at each period); (ii) the **modal choice motivations** leading to the observed modal share; (iii) the **route choices** for each mode; and (iv) the **flow evolutions** (number of vehicles and their occupancy, knowing capacities) for each mode. A primary objective in this direction is to propose valid simulation tools for each mode separately. However, in a truly multimodal perspective this means that moreover modelling tools are able to **reproduce the impact each mode has on other modes**. Simulation results of a mix of buses and cars on arterials is nowadays acceptable; however, this is not the case for example for the pedestrians exiting a metro station during peak hours and their impact on surface street flows.

Second, if one wants to optimize the modal share to reach a collective optimum of the transportation system, there is a need to be able to understand better what the **individual reasons for choosing one travel mode** or another are. Prices are not the only action lever.

Third, if the objective is to include multimodal trips into the possibilities offered to mobility system users, then the **intermodal articulation times (parking, waiting times) must be correctly included** into simulation tools. In particular, the potential benefits of articulation times themselves must be understood (for example the possibility to do some small shopping if a train station in included in the trip chain).

Transport means based on automated vehicles (especially fully autonomous vehicles) can provide a complete new set of mobility offers. There is no longer the need to find a parking slot in walking distance from the destination, one can be picked up right in front of the door as well as new sharing / car ownership models will show up. Most obvious is that no driver is required. This is of high importance as a driver is not only a cost-pusher of mobility services but there are also a lot of technical, labor-law and time related restrictions that disappear in case a driver is not needed anymore. To prepare transport planning and related traffic management measures it is important to **develop demand prediction models** able to deal with such disruptive transport supply changes. Much more than today they must be **able to deal with 'uncertainty'**. The uncertainty accrues as the final mobility service cannot be foreseen. It is the result of the technical revolution as well as the according legal and business processes.

Traffic management concepts and tools need to be prepared for the now upcoming **transition phase**. For this phase it is necessary to consider all road users, the motorized and the non-motorized, the automated and the non-automated. Furthermore, as automated vehicles can be introduced much easier if infrastructure and traffic rules are adapted to their needs, there will be high pressure in implementing these changes. We must ensure that they are harmonized and do not contradict transport control objectives. Especially the **experience of road users e.g. driving a non-automated car have to stay as similar as possible**. At least, if there are changes, traffic management concepts and tools need to consider them. In the same way it is important not only to distinguish between the different levels auf automation but also the **different traffic behavior** which will vary also within a certain level of automation.

Another important effect is that **connectivity** adds a lot of potential to automated but also non-automated vehicles. Their traffic behavior results for the interaction between different vehicles and the vehicle and its surrounding infrastructure including traffic management. Hence TM becomes part of a dynamic interaction. One has to ensure that the objectives of TM can be achieved within such a system and will not escalade and **run into unwanted rebound effects**.

Research Needs for Zero Accidents and Zero Emissions

Although improved considerably over the last 10 to 20 years, the current approach of the modelling of a transport system is way too coarse. Often, **models lack a human perspective**; they treat humans as a kind of (possibly faulty) controller, or even completely deterministic. This leads to difficult models when it comes to the modelling of traffic safety and traffic performance, and to models that do make sub-optimal predictions about what increases and what decreases traffic safety and performance.

Furthermore, the **modelling of the interaction between different modes of travelling**, as well as the **interaction between human-driven vehicles and partly or fully automated vehicles** needs a research boost that leads to a better description and which is then able to support the policy and management issues to do the best possible transport system planning, management and control. Finally, when it comes to the zero emissions goal, it is especially interesting to research and develop solutions that work with traffic with mixed engines, which may have a dramatic different footprint in emissions. Here, again, improved modelling that has also to deal with the question of how to **connect a model with online data** is truly important to make the best possible policy decisions.

Such an improvement of the modelling goes along with **much more complete solutions to traffic control**. This starts from solutions to **handle all the many new and old streams of data** and how to best utilize them for traffic management, to the extreme case not to change only the supply side to improve the traffic in the city, but to think of **creative solutions to influence the demand side** as well. This is especially important when an increase of the use of active modes of transport is sought – one downside of a future automated transport may be that it may increase the traffic and decrease the usage of active modes, and therefore a better management of the demand side might come handy here. When it comes to traffic control, a whole plethora of approaches need to be developed to reach the two zero goals. **An *urban transport system* that would be radically designed for zero accidents would have a completely different traffic control than it is today**. This may lead to concepts that do currently look very exotic like a slot-based traffic management: a certain trip with a certain mode is only allowed, when it does not have any chance to cause harm.

As mentioned already, the modelling issue of an automated and/or cooperative transport system is especially difficult when it comes to the complicated mixture of different technologies with different modes and different amounts of human influence. While the final goal of completely automatic and completely electric seems to be an almost trivial fulfilment to the zero accidents and zero emissions goal, the path towards this very long-term vision is much more complicated. Time and again it has been demonstrated, that such a mixture contains its own challenges and pitfalls, where it can only be hoped that an improved modelling will help to avoid them, or to design countermeasures. I**n the best cases, this transition is smooth, more likely is that it will contain some completely surprising inconsistencies, and in the worst of all cases, it may even decrease traffic performance and traffic safety. Therefore, better models and better means of control are needed** to make sure to avoid such hardships.

Research Needs for Minimum Space, Time, Energy & Costs for Transport

Road traffic congestion arises due to too high demand in relation to available capacity. Means for decreasing congestion include **measures to increase capacity, decrease demand, or decrease the total space-time used for a traveler to fulfill its travel demand**.

Intersections and merges are common bottlenecks that limit capacity. In the future, when connected automated vehicles reach high enough penetration rates, capacities of such bottlenecks might be increased by new traffic control approaches as **slot based traffic management, speed harmonization or dynamic lane division**. An introduction of self-driving vehicles also rise questions on optimization of speed for minimizing the energy used to reach the destination, given that the **arrival time might become more important than the actual travel time** if the travel time can be used for other purposes than driving the vehicle. There is a need to rethink traffic control from scratch and also ensure that new type of traffic control and traveler response to such controls systems are adequate modelled in traffic models to allow optimization of the designs of the controller and impact assessments.

Decreasing total travel demand is difficult but there are several possibilities for **decreasing demand for vehicle trips by optimizing the number of travelers and goods per vehicle**. Car-sharing, ride-sharing and demand responsive public transport are often mentioned as possible means for this. However, the impact of such systems on vehicle kilometers, congestion, etc. depends on the willingness of sharing vehicles and whether such systems are designed in competition or in cooperation to or as an integrated part of the public transport system. **Traffic impact assessment of shared solutions** require further development towards multi modal, traveler and trip based traffic models.

Travel demand, capacity and capacity utilization is often discussed from a vehicle perspective and not from a traveler perspective. Road capacity is defined in terms of vehicles and not travelers, persons and goods per hour. **How much space and time different modes occupy does not only depend on the level of congestion and the space each vehicle occupies, but on the space that each traveler occupies**. To allow for a more mode independent and traffic system performance assessment there is a need to investigate new metrics that **take the space, time, energy and cost for transport of the travel demand from a traveler point of view into account**. Private car trips with one traveler per vehicle occupy more space both while moving and when parked compared to shared solutions. The vehicle technology development towards automation might not only enable cost-effective shared solutions that decrease the space-time used for each traveler, but also decrease the space needed for parking or enable new smart parking management systems. However, the introduction of **shared solutions requires drop off and pick up areas, which also occupy space and need to be properly managed**. Thus, there is a need for development of new traffic management and control technologies for the shift from and to vehicle travelling to and from walking. Impact assessment of capacity and traffic performance effects are also needed.

Controlling the mobility system to make it optimal in terms of space and energy consumption, reduce the associated time waste and decrease globally the individual and social costs is not a doable goal without a correct set of assessments tools.
As we have explained before, a truly multimodal modelling tool is a necessity. This tool will allow the estimation of the consumption of energy, the space usage, the travel times and the individual and global costs. **This needs an enrichment of the possibilities of our present simulation tools.** For example, are we able to determine what the optimal speed of a journey realized with an individual car for a given infrastructure is regarding a multi-objective cost-function? Can we use modelling tools to assess the impact of a harmonization of the speed of the various vehicles occupying simultaneously a shared urban space? With this multi-objective cost-function, can we define the optimal modal share for a given travel demand? Can we consider not only the presently existing modes but also the future vehicles/ modes? More globally, what is the life-cycle cost impact of a ride/ car sharing based-mobility?

Our Scope

The ECTRI Thematic Group on Traffic Management deals with the following four topics: Traffic modelling, traffic control, impact of automated transport systems, and cooperative transport systems. These are detailed in the following.

Traffic modelling: to understand the impact on system performance (in multiple dimensions including comfort) of control methods correctly. Therefore, almost all transport system objects and their various interactions have to be modelled, starting from pedestrians and ending at automated vehicles as well as the surrounding infrastructure, which has not a passive role at all. In addition, we have to think about how to best utilize the many new data sources.

Traffic control: the classic approaches as well as new traffic control methods, have to be improved. Of interest are not only “hard” control methods, but also “softer” methods like providing information to transportation system users. Furthermore, a true intermodal traffic management has still to be invented. In addition, we have to think about how to best utilize the many new sources of data currently available and in future transport systems.

Impact of automated transport systems: on transport system performance is of special interest including heterogeneity of vehicles, vehicle types, modes of transport and level of automation. Even more, approaches such as mobility on demand for passengers as well as freight might improve under automated transport systems and they have the chance to shape tomorrow’s transport systems. Nevertheless, we should think about means to implement mobility on demand even outside of automated systems.

Cooperative transport systems: independent and in combination with automation will also shape future’s transportation systems. First implementations of cooperation are already in place in today’s transportation systems. Traffic management has to take as much benefit from this technological trend

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