CENTER FOR MOBILITY SYSTEMS

AUSTRIAN INSTITUTE OF TECHNOLOGY

SUSTAINABLE, SAFE AND DIGITAL: PERSPECTIVES FOR A HUMAN-CENTERED MOBILITY SYSTEM

Content

01 WORKING TOWARDS A HOLISTIC MOBILITY ECOSYSTEM

In our society, we take moving from one place to another for granted, hardly giving it any thought in everyday life. And yet, mobility is a basic human need and ultimately a determining factor of our humanity, comparable to our ability to abstract and communicate: Via mobility, we "make the world our own".

No wonder that mobility has always had predominantly positive connotations in our culture and is still associated with concepts such as freedom, cultural exchange and growth. At the same time, the downsides of unlimited mobility become increasingly obvious: first and foremost, the ecological impact, followed by capacity limits, health concerns and safety risks.

TRENDS AND FRAMEWORK

To design the mobility system of the future, a holistic perspective is required. The strong trends of contemporary society determine the framework.

Against the background of climate change, mobility is seen more and more critically: Buzzwords like CO_2 emissions, Dieselgate or flight shaming dominate the public discourse on the topic. Having everything available everywhere and at all times is taken for granted. E-commerce and globalised trade lead to a considerable increase in traffic volume – on international traffic routes, regionally and within cities. The advancing urbanisation poses extensive challenges to mega cities, towns and rural areas. Environmental pollution, traffic jams and noise exposure require innovative solutions. The digital transformation of almost all areas of life also brings fundamental changes in our mobility system. Autonomous driving promises more safety and the chance to optimise traffic flows. A diverse society and ageing population in Europe presents specific requirements for the mobility system. This includes the issues of participation and accessibility. Additionally – in the working world at least – the use of virtual reality could make many physical journeys, particularly long-distance, obsolete.

MOBILITY OF THE FUTURE – A PARADIGM SHIFT?

The question of what mobility of the future will look like has no clear answer. However, we do know that, on the one hand, technological advances bring about new modes of transportation (e.g. air taxis, hyperloops), alternative drive/propulsion technologies (e.g. e-mobility) and innovative mobility services. On the other hand, many physical journeys could become obsolete in the future, particularly for the working world: Even today, the use of virtual reality (VR) enables people to connect in the virtual world and collaborate on the same project across long distances. In the future, further research and development could pave the way for fundamental changes in mobility. Haptic holograms – that could make the virtual world literally tangible – are one example.

However, regardless of whether we use new means and modes of transportation to move very quickly and across long distances, whether we are mobile in our immediate environment, whether we go as far as replacing physical journeys by means of corresponding technologies – to avoid unwanted consequences, clear objectives are needed for the mobility system.

The EU H2020 Work Programme "Smart, green and integrated transport" states: "The priorities identified in this Work Programme will continue to pursue Societal Challenge (SC4)'s overall objective of achieving a European transport system that is resilient, resource-efficient, climate- and environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society." These terms are what any new mobility solution has to be measured against. However, conflicting objectives or unforeseen interactions between them cannot be ruled out. Identifying these, developing innovative solutions and examining mechanisms of action in an all-encompassing approach are major tasks for research. When designing the mobility system of the future, a holistic approach and careful planning are paramount to implement the – sometimes contradictory – objectives in the best possible way for society. The political body, industry, researchers and society: All stakeholders are called on to pull together to effect change.

02
DIGITAL TRANSFORMATION AS A CATALYST FOR CHANGE

The increasing digitalisation of all areas of life has reached mobility, speeding up change and presenting new perspectives. Autonomous driving and the integration of vehicles with the infrastructure and other traffic participants promise a higher level of safety and more efficient solutions. The prevalence of smartphones also constitutes a basis for new business models such as multimodal traffic platforms, sharing services and social innovations, e.g. participative planning tools.

However, digital transformation also holds dangers in the mobility context: The dystopia of the "transparent citizen" raises questions regarding the misuse of sensitive mobility data, for example. Ethical aspects have to be taken into account regarding automated or even autonomous vehicles, and adequate answers are needed for the risks in the field of cyber security.

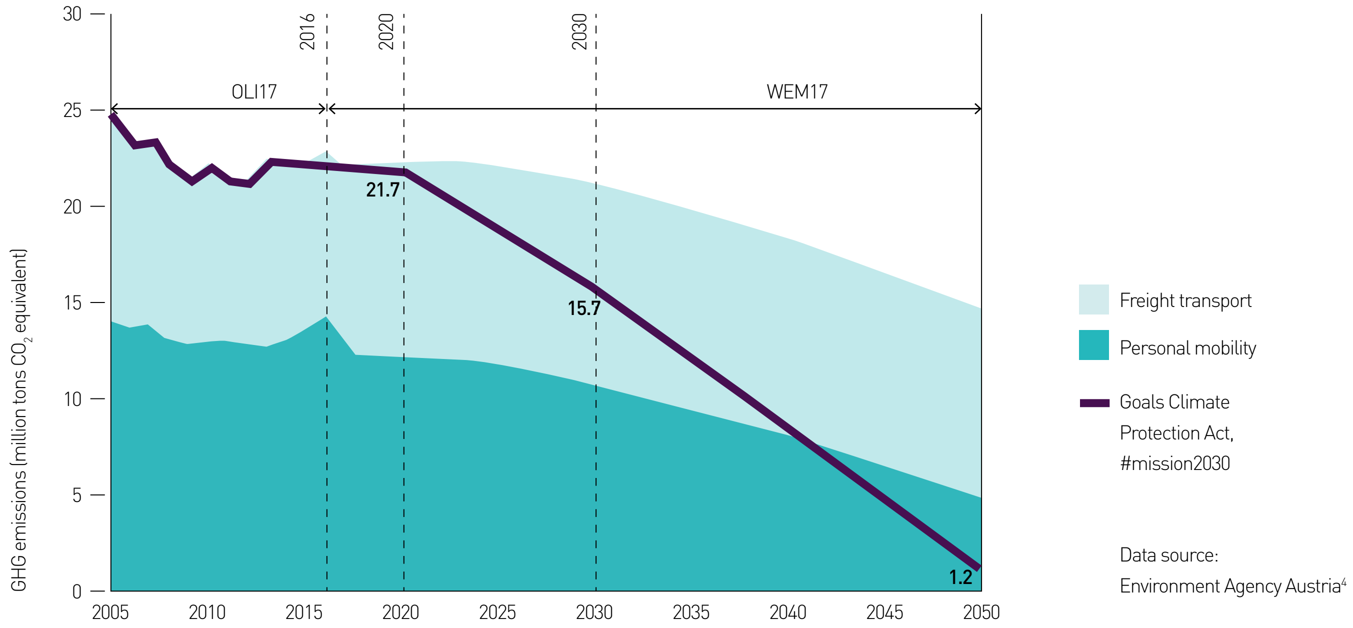
As research provides independent and evidence-based decision criteria to all stakeholders, it plays an important role in designing the mobility system of the future. Due to the ever-increasing amount of mobility-relevant data, the need for new methods of collection, analysis and interpretation of this information also grows. Additionally, applied research supports the implementation of new mobility modes and business models.

The following topics, among others, are made possible, speeded up or transformed through digitalisation in the mobility context:

- automated or autonomous driving
- big data analyses of mobility data (data with a space and time dimension)
- use of artificial intelligence and machine learning approaches to increase efficiency, traffic safety and convenience
- V2X: vehicles communicating with each other and the surrounding infrastructure
- vehicle communication with so-called vulnerable road users (pedestrians, cyclists etc.) to increase safety
- route planning and optimisation
- fleet planning and optimisation
- logistical systems of the future based on the Physical Internet
- impact assessments, anticipatory traffic planning and optimisation
- analysis and optimisation of pedestrian flows
- automated incident detection and accident prediction
- assessment and monitoring of traffic infrastructure (roads, bridges, tunnels etc.)
- predictive maintenance for asset management

Applied mobility research makes a significant contribution to creating and realising opportunities. It encourages innovations and new technologies, and provides a decision-making framework for society, industry, politics and administration – guided by the rules of good scientific practice, oriented to societal aims and driven by curiosity. The holistic point of view and the strict adherence to scientific rules and regulations enable mobility research to make a sustainable and extensive contribution to designing the mobility system – ultimately for the benefit of everybody.

GHG EMISSIONS IN THE TRANSPORT SECTOR



03
CLIMATE-FRIENDLY MOBILITY

The Paris Agreement in December 2015 was the first time that 195 countries ratified a common, global and legally binding climate protection.[1] With the EU acting as a trailblazer, Austria has pledged to contribute to limiting the global temperature rise to 1.5 degrees.[2]

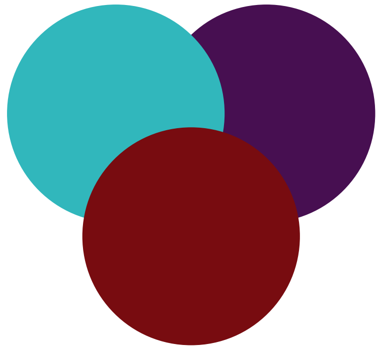
With a share of 28.8%, the traffic sector is the second biggest cause of greenhouse gas emissions in Austria. While these emissions were reduced in the other relevant sectors – namely energy and industry, buildings and agriculture – between 1990 and 2016, the traffic sector recorded an increase of 66.7% over the same period.[3]

The progress report of the Environment Agency Austria[4] shows that actions taken in Austria to date are neither sufficient to reduce greenhouse gas emissions in the traffic sector to 15.7 million tons of CO_2 equivalents by 2030, nor to reduce them completely by 2050.

The available data also clearly shows that mobility is a significant driver of climate change and that disruptive changes are required. Technologies such as electric mobility or the use of biofuels can make a considerable contribution for the traffic sector to reach the climate targets. However, they will not be sufficient to bring about a comprehensive turning point in mobility. New organisational forms of mobility are needed, and – above all – a change in the mobility behaviour of everyone.

[1] UNFCCC.int, 2019
[2] European Commission, 2019
[3] Anderl et al., 2018
[4] Heinfellner et al., 2018

EFFICIENCY – CONSISTENCY – SUFFICIENCY: THREE PATHS TO SUSTAINABLE MOBILITY



EXAMPLES FOR RESEARCH QUESTIONS REGARDING ENVIRONMENTALLY FRIENDLY MOBILITY ARE AS FOLLOWS:

How can the creation of a climate-neutral mobility system succeed?

How will changes in the mobility system impact the achievement of climate targets? (multi-dimensional modelling and impact assessment)

What is needed to advance a shift from motorised individual transport to public transport or active mobility modes (cycling, walking)?

What role does the infrastructure play in this context?

What is needed to advance the electrification of public and individual transport (e.g. design and distribution of the charging infrastructure)?

What are the prerequisites for sharing models to contribute to sustainable mobility? (car sharing, ride sharing, on-demand services etc.)

How can the outskirts and hinterland of cities be best integrated into the urban mobility system?

What contributions can companies make for their employees' mobility to be environmentally friendly?

What are the possibilities for making the transport of goods more environmentally friendly – internationally, regionally and within cities?

What would a mobility account have to encompass to make a significant contribution to climate protection on the one hand, and be fair and socially responsible on the other hand?

To achieve a climate-friendly mobility system, three different principles – efficiency, consistency and sufficiency – must be enacted.

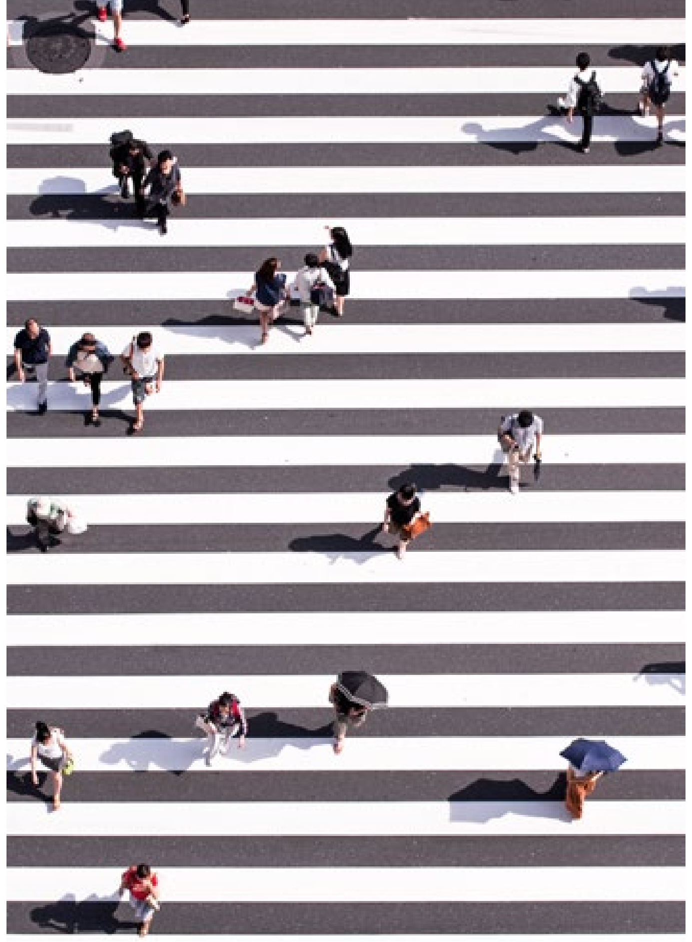
EFFICIENCY improves the ratio of resources used and results achieved. To give an example, in the mobility context, an engine with lower fuel consumption constitutes an improvement in efficiency. However, the principle reaches its limits as – more often than not – an increased efficiency is weakened or even voided by rebound effects: In the past, the development of more fuel-efficient engines did not lead to less fuel consumption; instead, customers bought more powerful cars or used their cars more frequently and for longer periods of time – due to the use of a more economical car incurring fewer costs. Still, a more efficient use of available resources through pooling and avoiding empty runs offer excellent opportunities – for example, on-demand services in areas with a low population density, where the alternatives are potentially empty public buses or having to rely primarily on private cars. Furthermore, it is both sensible and necessary to increase efficiency in the logistics sector to reduce CO_2-emissions for delivery traffic. Horizontal cooperation between competing delivery services has enormous potential to avoid empty runs – particularly in rural areas. Additionally, cities could alleviate problems such as traffic obstructions caused by double-parked delivery vans.

CONSISTENCY leverages the compatibility of nature and technology. One approach, for example, is to prevent negative ecological consequences of traffic by using biogenic fuels. As measures of consistency do not require users to forgo consumption, they are generally met with a high level of acceptance. However, these approaches frequently fail because they are technologically unfeasible or are economically unviable. Still, the principle of consistency contributes significantly to a sustainable mobility system: decarbonisation measures, by shifting to alternative engine types (e.g. battery, hydrogen), are to be welcomed. However, more research and development is required to make a holistic, CO_2-neutral and environmentally friendly mobility possible (including vehicle and engine production). Promoting active mobility (walking or cycling) and shifting the transport of passengers and goods from the road to the railways have to be mentioned in this context – along with using inland waterways to transport goods. The prerequisite is a traffic infrastructure that is oriented towards the future and makes sustainable mobility modes possible in the first place.

The principle of SUFFICIENCY aims at leading a resource-saving lifestyle. It asks for limiting the use of resources to a "sufficient" degree, in other words sustainable for the planet. Consequently, sufficiency strives to achieve a change in human mobility behaviour. Such measures are sometimes difficult to implement in society as they require foregoing consumption or changing consumption patterns. Having said that, sufficiency is regarded increasingly positively against the backdrop of the climate debate, as it is aimed at a responsible use of resources. An individual mobility account, for example, could show the highest acceptable amount of emissions for a person to "use" within a set period. However, we are far from realising such an approach, comprehensive research is needed. According to the principle of sufficiency, another possibility to use fewer resources would be the use of technologies like virtual reality to make many journeys from A to B obsolete.

Improve, shift, avoid: only a consistent combination of these three principles will make mobility with a low environmental impact possible in the future. Changing the individual mobility behaviour is certainly necessary. This can be achieved by using "shared" transport modes instead of motorised individual transport and engaging in active mobility like walking and cycling – and, in particular, by limiting mobility to preserve resources according to the principle of sufficiency. This also concerns the transport of goods: Sustainable logistics solutions and a change in consumer behaviour are major elements for a systemic solution. To advance it, courageous, anticipatory and possibly unpopular actions are needed. At the same time, lasting behavioural changes can only be expected if all stakeholders involved understand the users' needs and motivations, and adapt all accompanying communication accordingly. Research can make the decisive contribution by developing new technologies, showing alternative actions and finding answers.

04 SAFE SYSTEM APPROACH – SAFETY FOR ALL TRAFFIC PARTICIPANTS



Road safety is of great importance in Europe. The EU has set itself the ambitious long-term goal of reducing the number of traffic fatalities within the union to close to zero by 2050. In the medium term, the goals consist of halving the number of traffic fatalities and substantially reducing the number of the seriously injured by 2030. During the first 13 years in the new millennium, a decrease in traffic fatalities – from 54,000 down to 25,000 – was achieved, but numbers have stagnated since then.[5]

To reach these targets for Europe, safety awareness has to increase. On the one hand, decision makers are urged to provide financial means for preventative measures; on the other hand, they have to take safety into account when considering the implementation of other mobility measures. While a shift in the modal split from motorised individual transport to public transport contributes to an increase in road safety, a shift towards active mobility modes like walking or cycling might have the reverse effect. Safety risks for these unprotected traffic participants have to be minimised by means of an appropriate framework and adequate measures.

Questions of traffic safety in general have to take account of the interaction between humans, vehicles and infrastructure. Humans make mistakes and take risks in traffic – whether subconsciously or on purpose. In addition, introducing new technologies leads to behavioural changes in traffic participants. To give an example, the increased use of mobile phones led to higher levels of inattentiveness in pedestrians, cyclists and drivers. Advanced driver assistance systems make an important contribution to increasing active safety, but possibly also entice drivers to take more risks.

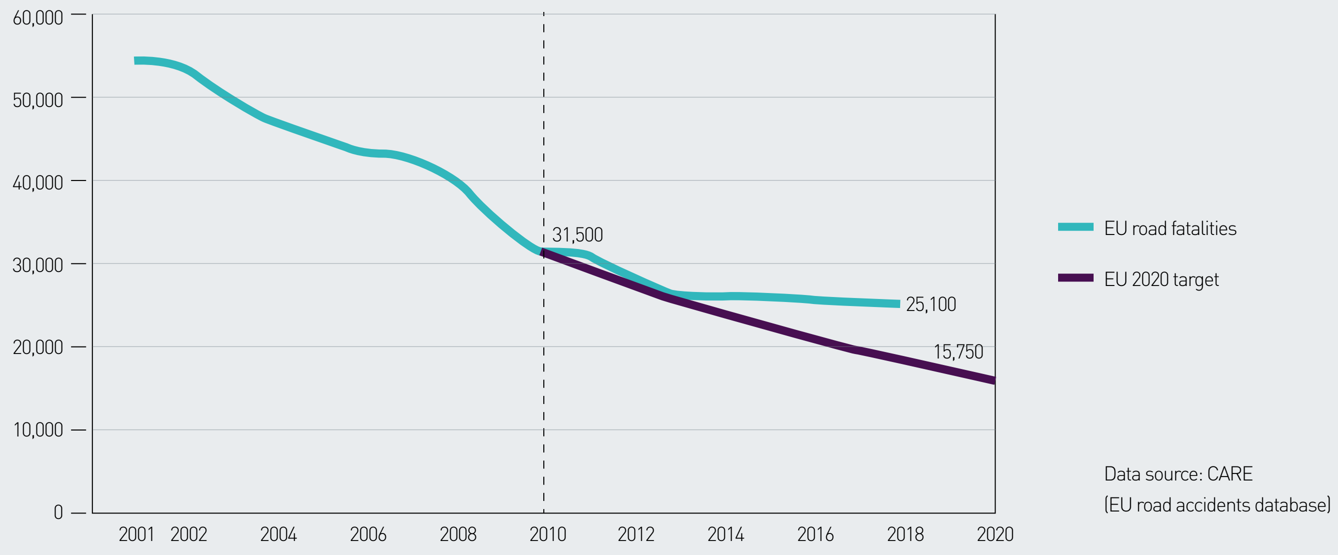
Consequently, vehicles and infrastructure have to be designed to be as forgiving as possible in order to limit the consequences of potential human error.

On the one hand, automated and autonomous vehicles and linking them with other traffic participants as well as the surrounding infrastructure promise enormous potential for an improvement in traffic safety; on the other hand, complex intra-urban environments still pose the biggest challenges for autonomous driving. There is a pressing need for research, particularly concerning the interaction between autonomous vehicles with pedestrians and cyclists. Modern methods for the observation and analysis of traffic conflicts and near-misses provide a basis for substantiated road safety measures.

In this context, infrastructure – by defining the framework – is of particular importance. To consider all traffic routes in a network and to sensibly design interfaces like pedestrian crossings and intersections between roads and cycle paths lays the foundations for the safety of all traffic participants.

[5] European Commission, 2019

EVOLUTION OF EU ROAD FATALITIES AND TARGETS FOR 2001–2020



POTENTIAL RESEARCH QUESTIONS FOR INCREASED ROAD SAFETY:

- Which measures have to be implemented to provide a forgiving traffic infrastructure?
- Which methods are best suited to efficiently collect safety-relevant data (road conditions, driving dynamics, trajectories, vehicle environment etc.)?
- What do accident prediction models based on big data analyses have to look like to deduce concrete preventative measures? How can the validation process work?
- How should novel mobility modes and transport means (for example autonomous and automated vehicles or electric micro-vehicles be integrated into the mobility system regarding road safety?
- What potential do technologies for connected and automated driving have in terms of safety? Where do new risks emerge in this context?
- How can artificial intelligence and machine learning approaches lead to an increase in safety?
- What do roads, cycle paths and footways have to look like to guarantee the safety of pedestrians and cyclists, particularly against the backdrop advancing of active mobility?

POTENTIAL RESEARCH QUESTIONS REGARDING EFFICIENCY AND RESILIENCE:

Which measures and technologies contribute to an efficiency increase for the mobility system as a whole?

In logistics, which measures could save time and cost, and increase ecological sustainability at the same time?

How does the use of available supply capacities have to be planned to be in line with efficient supply (and disposal) logistics?

In which fields of the mobility system can impact assessment of planned measures and interventions contribute to increasing its resilience?

Which methods are suited to the identification of potential bottlenecks and weaknesses to take prior measures in order to increase resilience in the mobility system?

05 EFFICIENCY AND RESILIENCE IN THE MOBILITY SYSTEM

As mentioned previously, the advancing digitalisation and corresponding availability of more and more data open up new possibilities and efficiency increases for the mobility system. Using big data technologies permits the design of comprehensive traffic models – including available transport means and transport infrastructure. This, in turn, allows for the effects of changes to be simulated prior to their implementation. With such an impact analysis, particular attention has to be paid to the human factor. Which needs have to be met for the system to be as "human-friendly" as possible? Faced with a mobility eco-system that is becoming ever more complex, modelling provides a sound basis for planning and decision-making.

Digital transformation and automatisation can also lead to efficiency increases for logistics and the transport of goods. Particularly in fleet management and route planning, the full potential for optimisation has yet to be tapped. Research is a reliable partner in this context. Based on complex mathematical modelling, it develops solutions to lower costs, saves time and increases the environmental sustainability at the same time. When it comes to the efficient use of infrastructure, buildings and transport hubs, new methods in the planning process already exist. This includes the analysis and simulation of passenger flows to guarantee an efficient sequence of events (e.g. passengers getting on and off trains) and the safety of everybody involved (e.g. in case of evacuation).

A mobility system's resilience becomes apparent during unexpected events – for example road closures after accidents and terrorist attacks, or damage caused by natural disasters. A mobility system that has taken these eventualities into account, will remain functional even under difficult circumstances by ensuring that people and goods can still get from A to B.

Methods of impact analysis form the basis for evaluating the resilience of a mobility system: What happens, if a road or bridge can no longer be used? Which traffic flows are critical? How can they be kept up and running in case of emergency (e.g. medical supply logistics)? Where do infrastructural bottlenecks exist and how can they be eliminated? Appropriate tools and simulations make contingency planning possible before critical events happen. They assist providers of transport infrastructure to implement suitable, anticipatory measures in advance.

06 RELIABLE TRANSPORT INFRASTRUCTURE

Providing a reliable and forward-looking traffic infrastructure is an important prerequisite for the mobility system of the future. Further to roads, cycling paths and footpaths, this includes buildings, railway tracks, bridges and tunnels as well as supporting structures and noise barriers.

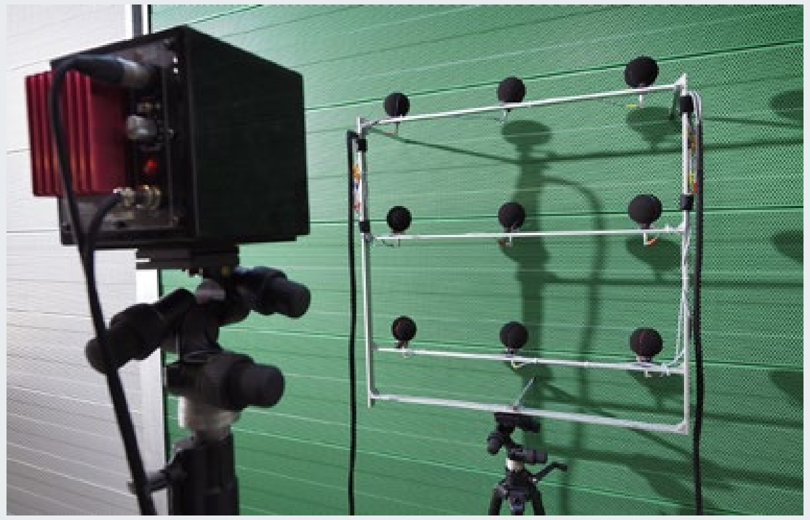
At present, these structures and buildings are subjected to an increasing strain – caused by higher traffic volume, changed dynamic load and exacerbated climate conditions. To give an example, the impact of truck platooning and so-called gigaliners on transport infrastructure should not be underestimated. In many countries, the advanced age of structures and buildings makes the situation more precarious. Furthermore, there are higher demands regarding availability and safety as well as the protection of natural resources and budgetary limits.

To preserve a functioning transport infrastructure, two conditions have to be met: A continuous assessment programme is required, for example inspecting bridges and surveying road surfaces, and – based on these results – predictive maintenance.

Digitalisation also provides new, efficient solutions in this field. Examples include real-time monitoring of structures (instead of routine surveys at longer intervals), minimally invasive or contactless inspection methods and predictive maintenance based on modelling. For the assessment of road conditions, innovative technological solutions make comprehensive data surveys and analyses possible – for an effective portfolio-management and the prioritisation of planned measures. Mobile, high-performance measuring vehicles register all relevant conditions of the road surface and objects in the road space in a single run, without obstructing traffic. For asset management, this results in new possibilities for significant cost-savings at the same time as an increase in safety.

It is essential to design transport infrastructure in a way that reduces traffic noise to a minimum, particularly against the backdrop of the environmental sustainability of mobility. Road surfaces have to be noise-absorbing without losing grip, and noise barriers have to be built and positioned to provide the best protection for residents. Through novel measurement techniques and in-situ tests, innovative research approaches contribute significantly towards making traffic quieter and thereby more tolerable.

Considering the extended lifespan of transport infrastructure, all measures have to be examined regarding long-term dependencies in the system. Today's infrastructural planning has to take into account potential changes in user behavior – through automated vehicles and additional stress caused by climate change (heat damage, flooding etc.), for example.



POTENTIAL RESEARCH QUESTIONS FOR A RELIABLE INFRASTRUCTURE:

How can access to transport infrastructure at all times be guaranteed despite increased use (higher traffic volume, ageing buildings, natural hazards etc.)?

Which novel methods and tools are required to ensure a condition assessment for structures and buildings (roads, bridges, tunnels, train tracks, supporting walls etc.) that is of a high-quality, continuous and all-encompassing?

How can this data be applied in simulation models for predictive maintenance to ensure a safe, cost- and resource-saving use?

How can noise protection measures be evaluated? How can traffic noise be minimised directly at its source (rolling noise caused by tire-road-interaction)?

How can sensible and consistent data management for the lifespan of traffic infrastructure be guaranteed?

07 FOCUSED ON HUMANS

Technological progress and novel transport services change the way humans live, work, move and interact. It is for us to decide to not only react to this process, but to proactively shape it – for the benefit of the individual and society. This is where research comes into play. To implement the right measures at the right time, it is essential to understand, interpret, identify and influence changes in the mobility system accordingly, along with their potential implications.

How can technology contribute to both satisfying the human need for mobility and shaping mobility in a way that is climate-friendly, affordable and safe? Working with the assumption that technological progress aspires to improving everybody's quality of life, it is even more important to take into account potential consequences during the development process. Both users (individuals moving around, in the widest sense) and those affected (residents, for example) have to be considered – particularly because these roles are fluid, as almost everyone is both user and a person affected in one way or another.

How does a human-centered mobility system have to be designed? Using mobility services should be as convenient and easy as possible, and deliver a positive user experience. Only then will acceptance and behavioural change happen. Mobility should be accessible to everybody: people with special needs, from all income-brackets, and both in cities and rural areas. In addition, a human-centered mobility system takes varied user needs in diverse situations and different stages of life into account. It also allows for multiple usage scenarios of public areas like roads and squares.

Last but not least, mobility also has to take human health into account. The World Health Organization considers noise one of the most critical environmental health risks.[6] Against this backdrop, noise reduction and prevention measures make an important contribution to improving the population's health and well-being. A change in the modal split towards active mobility also influences health positively. Furthermore, the social component has to be considered in a mobility context.

6 Euro.who.int, 2019

EXAMPLES FOR RESEARCH QUESTIONS REGARDING HUMAN-CENTERED MOBILITY ARE AS FOLLOWS:

How do technological solutions have to be designed to actually fulfil human needs? How can these needs be captured?

How can the potential of advancing digitalisation in the mobility system be successfully used to achieve societal solidarity? How can society drifting into two- or multiple-class societies be counteracted?

Which factors influence the individual choice of transport? How can user decisions be influenced, for example through incentives, funding, the infrastructure and the configuration of the transport means on offer?

From an architectural perspective, what is required to design urban and rural environments to meet the users' needs? Which role does mobility play in this context?

How can digital transformation support a dynamic use of road space (parking spaces, delivery zones, outdoor dining areas, recreational use etc.)?

Which measures can contribute to ensure inclusive and barrier-free mobility? How should the increasing digitalisation be handled in this context?

How can transport-induced noise and vibrations be reduced to avoid negative consequences for a population's health and well-being?

… AND WHERE DO WE STAND TODAY?

It is clear: While the mobility of people, goods transport and the associated infrastructure used to exist in parallel, this system is increasingly replaced by a systemic interaction – based on new technologies as well as stakeholder interests and business models spanning across these fields. An integrated view of personal transport and logistics – together with a flexible use of the infrastructure – opens up new perspectives for the mobility of the future.

At the same time, the mobility system ought to be ecologically sustainable, efficient, safe and resilient, and satisfy individual needs. A holistic view and the close cooperation of all stakeholders are required to find sensible solutions in both economical and societal terms.

Research and development makes a significant contribution in this context: a comprehensive know-how of the system, scientific excellence and international cooperation make it possible to find answers to the most pressing questions in the mobility context – and to provide industry and society today with the solutions of tomorrow.

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

The AIT Austrian Institute of Technology is Austria's largest non-university research institute. With its eight Centers, AIT regards itself as a highly specialised research and development partner for industry. Its researchers focus on the key infrastructure issues of the future: Energy, Health & Bioresources, Digital Safety & Security, Vision, Automation & Control, Mobility Systems, Low-Emission Transport, Technology Experience and Innovation Systems & Policy. Throughout the whole of Austria – in particular at the main locations Wien Giefinggasse, Seibersdorf, Wiener Neustadt, Ranshofen and Leoben – around 1,300 employees carry out research on the development of those tools, technologies and solutions that will keep Austria's economy fit for the future in line with our motto "Tomorrow Today".

CENTER FOR MOBILITY SYSTEMS

Mobility is a fundamental core element of our society. At the Center for Mobility Systems, around 100 experts are developing holistic mobility solutions for the future based on the interrelation of passenger mobility, mobility of goods, and transport infrastructure. Efficiency, safety, ecological sustainability and the human factor are at the heart of the research and development efforts. Leveraging comprehensive system know-how, scientific excellence, market knowledge, and many years of international experience, AIT experts are using innovation to lead industry and society into the future of mobility.

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