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International Transportation

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Urban freight, urban transport

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Smarter on the move

Green transport and digital mobility

Transport must get serious about cutting carbon

Humans don't enjoy being stuck somewhere. We like to move, go places. In fact, man values this mobility so much that he created extraordinary tools to get from A to B, starting with the wheel and not ending with the airplane.

We value our freedom of movement because it generates such incredible value for us. Imagine for a moment that all the means of transport you are using have disappeared: Not that easy to get to work. No fresh groceries in the supermarket. You will need to walk to the doctor despite that sore knee.

Conjecture? Not for millions of people around the world who lack in access to transport – and therefore to the things that transport provides access to. There are still children that do not go to school simply because they cannot get to school. It's the same for health services and jobs. And it's true for the larger economy as well – well-connected countries tend to thrive; those that do not struggle to bring their goods to world (or indeed national) markets.

We won't be easily persuaded to give up the freedom to hop into a car or on a plane. On the contrary, billions of people in the emerging economies are discovering the advantages – and joys – of modern-day mobility. If anything, global demand for transport will grow.

In itself that is not a bad thing, but only if we manage to – among other improvements – decarbonise transport. Today, our mobility is almost completely driven by fossil fuels. Transport emissions make up almost a quarter of all CO_2 emissions from fuel combustion – by 2035 the share could reach 40%, which would make transport the world's largest emitting sector. Even the electricity for electric cars or for trains often comes from coal or oil-powered plants.

The link between mobility and harmful CO_2 emissions *must* be broken if we want to continue to remain as mobile as we are. If governments were forced to limit mobility in order to save the planet, the economic, political and human costs could be huge.

The better way is to provide carbon-free transport. Around 1900, the majority of cars in New York City were electric – let's go back to the future. In Africa, shared mobility has been the norm for a long time – let's learn from the experience of others. We need to be clear that technological progress alone will not solve the problem. To decarbonise transport over the next 35 years or so, all the levers we have at our disposal need to be aligned towards this goal. Many of these are outside the transport sector: digital connectivity and 3D printing may make some passenger and freight transport superfluous in the future. Tools that better allocate existing capacity reduce traffic (the average car is idle 23 hours per day). Innovative urban land use policies can be highly effective in reducing the need for travel.

The International Transport Forum is launching a major initiative to help achieve this alignment of policies. Our Decarbonising Transport project will provide decision makers with an effective tool to develop a road map towards CO_2-free mobility, and then help to navigate it. It will allow governments and enterprises to test and gauge the impact of individual actions in a highly complex and interdependent reality. More about it at *www.itf-oecd.org*.

The Decarbonising Transport project is built around three core elements. The first is COP21. The text of the Paris agreement doesn't mention the word transport. Neither do most national commitments by the signatories (and those that do are heavy on generalities and wishful thinking). But nations are finally embarking on a step-by-step pathway towards decarbonisation with reviews of progress every five years from 2020. This creates a huge challenge for transport: It is now up to the sector to demonstrate how carbon-free mobility can be achieved. If it doesn't succeed, transport runs the risk of becoming the outlier and everyone's favourite bad guy.

Second: the data. The Decarbonising Transport project will evolve around in-depth *quantitative* analysis. Our ambition is to federate existing data and knowledge on transport to create the most comprehensive model of global transport activity to date. ITF has strong in-house modelling, and we are already reaching out to potential partners to link up existing models and leverage their collective power to become more than the sum of the parts. Decision makers will be able to use the simulations to calibrate their emissions reduction actions.

The third characteristic of the Decarbonising Transport project is that it will be *inclusive*. The modelling will serve dialogue and mutual learning among a broad set of partners who are joining forces to design the roadmap towards carbon-neutral transport. Governments, corporations, universities, multilateral institutions, foundations, NGOs will all have their place and contribute knowledge, data or money. Nineteen major international companies are already involved through the ITF's Corporate Partnership Board, in which the project is anchored.

The Decarbonising Transport project will be officially inaugurated on 19 May, at the ITF's 2016 Summit in Germany. We plan to present intermediate results a year later. And by May 2019, we want the modelling to be robust enough to provide effective support to the 2020 reviews of COP emissions reduction commitments.

This is an open project, and very much a work in progress. All who have an interest in helping to make our mobility, and therefore our way of life, sustainable are invited to become part of the effort.

José Viegas
Secretary-General, International Transport Forum

Internationales Verkehrswesen

International Transportation

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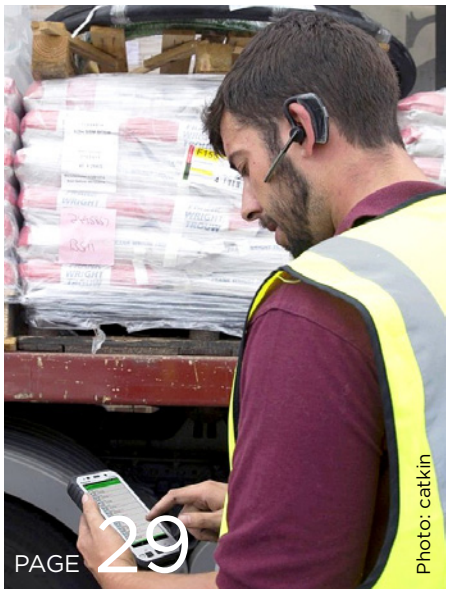

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AT A GLANCE

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Comparison of automated transport modes

Synergies for driverless rail transport

Transport systems, driverless transport, traffic management

Automatization takes place in daily life in nearly all areas. Smart watches, smart phones and smart homes are nowadays quite common. The future of transportation will surely follow this technological advancement.

Authors: Viola Klingkusch, Yigit Fidansoy

The increasing demands placed on transportation, demographic change and new technologies bring new challenges for the future of the transportation systems. Automated transport modes are being developed to reduce the costs and increase the capacity of current systems.

Definition of driverless transport

Over the past decades, the technologies used in the different means of transport have become more and more complex with the aim of enabling driverless transport. An automated transport system can be defined as a system where the driver of the vehicle is partially or fully replaced by an advanced electronic system. Those systems consist of computers, sensors and communication devices in the infrastructure as well as in the vehicles. Driverless vehicle technology has the potential of being a true game changer in traffic management. It delivers major benefits in terms of road safety, social inclusion as well as emission and congestion reduction. Transport automation involves the development of the required physical and digital environment, education and acceptance of end users, technological solutions and much more. In this paper the following modes of transport will be discussed: road, air and rail traffic (see *figure 1*).

The current situation

There are six levels of automation in motor vehicles. Between level zero, in which there is no driver assistance system, and the most highly automated level without a driver, there are four other gradations: assisted

driving, partially, highly and fully automated operation. Driverless operation is also referred to as 'autonomous operation'. In road transport there are already assisted and partially automated vehicles, in which systems take over longitudinal and transverse guidance for specific use cases. The car is monitored by the driver. There are currently highly automated vehicles under development that require the driver to intervene only in critical situations.

For the automation of the flight process, eight different stages of development are distinguishable. Between level 1, where manual flight guidance is introduced, to level 8 with fully automated autonomous flight operation, there are several gradations of assistance systems. It can be assumed that the degree of automation in the cockpit will continue to rise. There are arguments for active intervention of the pilots in the flight control in case of a complete system failure. Pilots must be able to intervene in cases of aircraft control failing. Very few maneuvers and trajectories are standardized. Essentially, a pilot can respond more flexibly than a computerized assistance system.

According to the International Association of Public Transport (UITP), there are four different Grades of Automation (GoA) in rail transport. The first grade is manual train operation, where a train driver controls the train run. In GoA 2, the driver triggers the movement of the train, which then stops at the next station automatically. This grade is called semi-automatic train operation. In railway systems, some mechanisms of the 2nd and 3rd level of automation have already been implemented. An example for GoA 2 in Germany is the subway in Munich, where the driver only opens and closes the doors. Driverless train operation with automated starting and stopping is called GoA 3, but a train attendant operates the doors and drives the train in case of an emergency. The highest level of automation, where no staff is needed on board, is called 'unattended train operation'. The train starts and stops automatically, operates the doors and handles emergencies. There are also some metro lines with GoA 3 and GoA 4. An example for GoA 4 in Germany are the metro lines U1, 2 and 3 in Nuremberg.

When comparing the number of automation levels in the three different transport systems, it becomes clear that there are many more gradations in air traffic. The reason may be that with aircraft more parameters need to be automated. There are many more sensors installed and needed as in other modes of transport.

Figure 1: Status quo of road, air and rail transport automation

Differences between legal frameworks

In the area of driverless transportation, legal liability and registration is essential for a legal framework. For road traffic, the Vienna Convention on Road Traffic of 1968 was designed to standardize the international traffic rules. In Germany, the requirements of this convention have been implemented in the Road Traffic Regulations (StVO). The Vienna Convention defines that the assistance systems used must be actively controllable by the driver, which in some cases is limited by the assistance systems themselves. Some of the assistance systems, such as ABS or ESP, become active when the driver is about to lose control of the vehicle. This raises the question of how far the 'driver' is able to monitor a driverless car and to what extent he may turn away from the driving task. Article 8 of the Vienna Convention can be interpreted in a way that monitoring of assistance systems is not necessary if the licensing regulations are

changed. Besides the registration, the liability of driverless cars needs to be discussed.

The legal basis in Germany for air transportation is created by the Civil Aviation Act (LuftVG), the Air Traffic Regulations (LuftVO) and the Certification Specifications for Large Aeroplanes (CS 25). The CS 25 states that the pilot should always be able to take control of the aircraft. An assistance system provides additional safety, because ideally both, the pilot and the assistance system, have an effect on the aircraft. The so-called type certificate is the official approval of a new type of aircraft for air traffic. The aviation authority of the state in which the aircraft is registered issues the license. In Europe the European Aviation Safety Agency (EASA) is responsible of the type certificates. The EASA regulatory framework differentiates between development, production, maintenance, and airworthiness of aircrafts. All changes, additions or repair procedures on the aircraft must be approved separately.

In case of rail traffic, the rules for driverless transport are different for trams and railways. Trams and some light-rail systems in Germany are planned and operated according to the Ordinance on the Construction and Operation of Street Railways (BoStrab). The Technical Rules for Trams for driving without driver (TRStrab FoF) are derived from BoStrab and specified for autonomous driving. The other important German regulation is the Ordinance on the Construction and Operation of Railways (EBO), which specifies rules and regulations for railways. Currently there is no specification for driverless transport in the EBO, which is an obstacle for the topic. Trains running under EBO are approved by the Federal Railway Authority (EBA). Tram licenses are issued by the Technical Regulation Authorities (TAB).

Driver assistance systems

Driver assistance systems in cars are additional electronic devices integrated in the vehicles to assist the driver in driving situations. They exert semi-autonomous or autonomous influence on the control, drive or signaling devices of the vehicle. Autonomous vehicles work without any intervention of a human driver. Assistance systems actively inform and warn drivers, increase comfort by stabilizing the automobile, thereby reducing the driver's workload.

The development of aircraft systems in the past has been influenced and shaped by the steady increase in air traffic, the demand for higher safety, greater efficiency in flight operations and the use of new technologies. No human pilot is beyond making mistakes during a flight and therefore has limits. The objective of assistance systems in aircraft is therefore to reduce the workload of the pilot. The special feature of air traffic is that it involves three-dimensional control variables, which an assistance system must be able to control. For larger machines, such as passenger aircraft, there are three-axis autopilots where in addition the rudder can be controlled. More complex systems also adjust engine power, communication and navigation for aircraft control.

The assistance systems that are planned for railways can be divided into driver assistance systems and network-related assistance systems. Driver assistance systems give speed recommendations to save energy and reduce wear. Network-related assistance systems focus on a specific network segment in order to optimize train movement in this area. This means that the position of the trains relative to each other should be optimized to save energy. These systems work basically with a 'green wave' principle like in road transport. In addition, the disposition, punctuality and capacity are in the foreground of network-related assistance systems.

Challenges for driverless rail transport

For the implementation of Automatic Train Operation there have to be far-reaching changes to the railway tracks, the stations, the signal boxes, the vehicles and the operation processes. There is a need for further research. A limitation of the spatial extent seems necessary for autonomous operation. Reasons for this are mainly the high cost in planning and retrofitting the infrastructure, the rail vehicles and the operating centers. A spatial limitation of the tracks in form of a fence is considered too complex and costly. The cost of reconstruction on the tracks and in the stations is rather high. In Automatic Train Operation there is a change in safety-related technologies. Achieving safety of the railway tracks can be considered difficult.

Through the use of assistance systems not only driverless driving is possible, but there also is a high potential of energy savings. However, the potential savings are dependent on the degree of automation, i.e. how many assistance systems are used. The realization of an automatic railway track requires a long planning period. Additionally, the duration of rebuilding the tracks and railway stations is of great importance.

An important aspect in the implementation of an Autonomous Train Operation is the acceptance of different groups of people who may be affected by such an introduction. The operator may be in favor of driverless operation after conducting a positive economic study. Opposition will probably come from the train drivers and, to a certain extent, the passengers. Train drivers are afraid of losing their jobs and being patronized by technical means like assistance systems. Tasks that were previously handled by a human must now be carried out by technology. Thus the risk of human error can indeed be reduced and at the same time safety can be increased by a redundant installation. The passengers may have fears of highly automated technologies because they do not see them as reliable.

Summary

In recent years a lot of research in the field of driverless transportation has been done. In the means of transport, be it airplanes, cars, or trains, there are different approaches to achieve driverless transportation. Yet the differences and similarities between the means of transport and experiences from present automated operations can be used to advance the automation grade. The challenges involved are not only of a technological, but also of a political and social nature. ■

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Green vehicles

The trade-off between environmental and climate policies

Climate policy, environmental policy, regulation, alternative fuel vehicles

The transport sector faces regulation by environmental and climate policies that aim to reduce the external costs of the sector that have to be acknowledged by all of the market players. Whereas environmental policies aim to reduce local air pollution, the goal of climate policies is to reduce global climate change. In practice, implementation of these policies involves some trade-offs. As a consequence, environmental and climate policies must coexist and innovations in the transport sector have to be assessed within the context of the broad technological change occurring in the energy system.

Author: Antje-Mareike Dietrich

Due to the historical manipulation of diesel engines by at least one German car manufacturer, namely Volkswagen (VW), regulations in the automobile market have attracted public attention. The VW affair shows that the political objections to these regulations are diverse and that they can differ among regions and policy fields, specifically in environmental and climate policy. It is necessary for all of the players in the market to understand the different objections and consequences of action in both policy fields. A brief analysis shows that trade-offs exist between environmental and climate policies.

Both environmental and climate policies equally address the issue that automobile usage affects environmental resources. At the local level, pollutant emissions include nitrogen and sulphur oxides, hydrocarbons and particulate matter. The consequences are negative impacts on human health and ecosystems. A high concentration of pollutants in the air causes respiratory ailments, mucosal irritations and raises the risk of cancer for humans. Additional negative effects are over-fertilisation, acidification of the soil and water, or damage to plants. Areas of high population density, especially areas that surround busy roads, suffer the most [1]. On a global level, carbon emissions from the transport sector contribute to the growing concentration of greenhouse gases in the atmosphere. This so-called manmade greenhouse effect is linked to droughts, flooding, species extinctions and other natural disasters [2].

In general, from an economic point of view, a clean environment and a stable climate are public goods with characteristics of non-excludability and non-rivalry in consumption. This means that no one has to pay a price for consuming a public good and can therefore use it as much as he or she likes. Because of the non-rivalry, the consumers do not affect each other by consuming the same good. However, in case of the air, atmospheric non-rivalry only exists to a certain emissions concentration limit corresponding to a certain number of kilometres travelled by car. Once the concentration exceeds the limit, further car usage causes the above stated negative effects for local residents and the global population. Usually, the individual car user does not take these effects into account because he or she does not have to compensate the people affected by these negative effects. In other words, the combination of non-excludability and rivalry leads to external costs that are borne by society.

Figure 1 shows that 42 % of the external costs of transportation in the European Union (EU) relate to carbon (CO_2) and pollutant emissions. Climate change has the largest share, with 29 %. Together, air pollution, nature and landscape, biodiversity losses, and soil and water pollution have a 13 % share. As shown in *figure 2*, 93 % of total external costs arise from road transport. Passenger cars are responsible for two-thirds of the total external costs [3].

Economists suggest different methods for addressing external costs. The aim of all

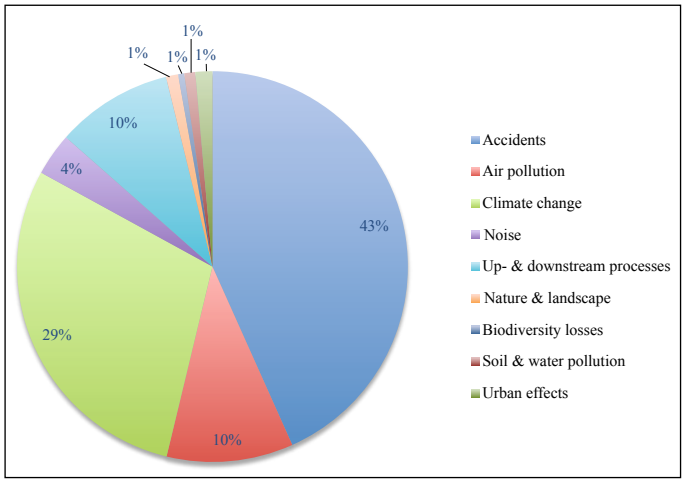

Figure 1: Share of external costs of the transport sector Source: [3], p.11

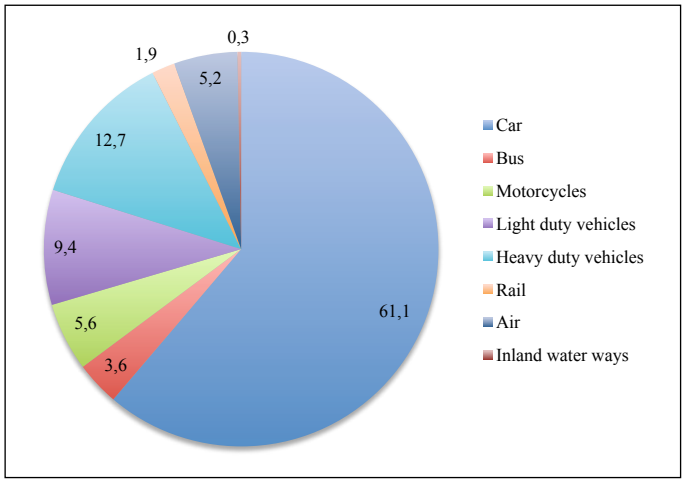

Figure 2: External costs per transport mode Source: [3], p.12

measures is to internalise these social costs, which means that the involved parties pay the costs. Generally, thresholds, Pigou taxes and tradeable emission permits are recommended. Several factors have to be considered in deciding what method should be used. Thresholds are superior in cases of overall limitation of pollutants over a certain region and when the marginal costs of avoiding the emission are equal for all producers. Taxes are a good method to avoid cost differences and in cases where avoiding emissions is not critical. Tradeable emission permits combine both approaches by limiting the emissions to a certain amount and allowing for avoidance of the emissions where the avoidance costs are low. All of the approaches consider the external costs of emissions and the costs of avoiding them. Thereby, zero emission is only an option if external costs are infinitely high.

With regard to car usage, it is reasonable for regulatory agents to choose different instruments for different emissions. At this stage, the differences between environmental and climate policies are crucial. While environmental policies address local pollution, climate policies aim to solve global climate change. Consequently, environmental policies should follow a local approach and climate policies should follow a global one. In theory, environmental and climate policies complement each other.

In the EU, environmental and climate policies work with different instruments in the car market. Addressing air pollution, the EU Directive on Ambient Air Quality and Cleaner Air for Europe [4], pursuant to article 1, aims at avoiding, preventing or reducing harmful effects on human health and the environment as a whole. Therefore, emission limits for particulate matter, lead, sulphur dioxide and ozone are mandatory. As a consequence, the Fuel Quality Directive [5] and type approval of motor vehicles [6] have obligated the transport sector to contribute to these environmental aims. Since 2000, only fuel without lead is allowed in the EU and, since 2011, the sulphur content is limited to 10 mg/kg. The type approval is carried out for each model sold in the EU. In 2015, the Euro 6 standard was implemented and the vehicle manufacturers have since had to meet the emission limits for carbon monoxide, nitrogen oxide, hydrocarbons and particulate matter listed in table 1. The test procedure for the type approval is standardised. Because it does not allow testing real-life emissions, it is going to be replaced by a new procedure in 2017. [7]

The EU regulations also address the carbon emissions of the transport sector. Since 2012, car producers must consider the carbon emission performance standards when selling their vehicles in the EU. Pursuant to article 4 of Regulation (EC) No. 443/2009, the average specific emissions of carbon dioxide must not exceed the specific emissions target of 130 g of CO_2 per kilometre (g CO_2/km). By 2020, the target will drop to 95 g of CO_2/km. Furthermore, according to the Fuel Quality Directive, the lifecycle greenhouse gas emissions per energy unit have to be reduced by 10 % until 2020. Fuel sellers have to plan for this.

In addition to the EU regulations, national governments have implemented some of their own regulations. In Germany, for example, car users have to pay an energy tax on motor fuel [8] and an annual tax on motor vehicles [9]. The implementation of energy taxes is attributed to the negative environmental effects of vehicle usage. The German motor vehicle tax has a component addressing climate matters because its rate depends on the quantity of CO_2 emitted per kilometre. Especially when taking the national level into account, the mixture of political instruments becomes apparent. First, there are measures that are clearly motivated by environmental policies, such as the Fuel Quality Directive and type approval, with the aim of reducing air pollution. Moreover, the carbon emissions target aims to contribute to European climate policies. Finally, national governments try to address both policy fields. All of these instruments simultaneously affect the car market.

A closer look at the technical implications of such a policy mix shows that there are limitations to satisfying both policy fields simultaneously. Most vehicles are powered by an internal combustion engine. For those engines, reducing air pollution requires cleaner fuel combustion. In contrast, reducing CO_2 emissions implies a decrease in fuel consumption. Cleaner fuel combustion is achieved by installing a catalytic converter and particle filters. Alternatively, running the engine on petroleum or natural gas, synthetic fuels or bio fuels instead of gasoline or diesel could also reduce air pollutants. Nearly zero local pollutant emissions are possible when electric motors are used. Currently, catalytic converters and particle filters are a common method for meeting the EU emission standard. Nevertheless, the emission standards for particulate matter and ozone are exceeded too often, especially in urban centres. This is mainly caused by high traffic volumes. [10]

A decrease in fuel consumption is possible by reducing the vehicle's driving resistance or enhancing its combustion efficiency. Tires with a low rolling resistance, improved aerodynamics and light-weight components all affect the driving resistance of vehicles, regardless of the propulsion technology. There are also options for enhancing the combustion efficiency of gasoline and diesel motors such as motor downsizing, direct fuel injection, variable valve timing or cylinder shut-off. Unfortunately, some of these measures such as direct fuel injection entail more air pollutant emissions. Therefore, converters and filters are necessary, in turn reducing the motor's combustion efficiency. [11] Direct fuel injection is widely used for diesel engines; here, the dilemma of environmental and climate protection becomes obvious. By manipulating diesel engines within the test procedures, the car manufacturer VW wanted to meet the emissions standards for type approval with a relatively fuel-efficient propulsion technology. The testing procedures in the US market revealed that it is difficult to satisfy both standards simultaneously in real life conditions, at least when conventional propulsion technology is used.

Promising technical options for solving the dilemma are bio fuels or gases, synthetic fuels or gases, and the shift to electric-powered engines. Crucial for all fuel options is the amount of life-cycle greenhouse gas emissions and the total pollutant emissions of the energy source used to power any type of engine. Due to this, it is not reasonable in most countries to widely use electric-powered vehicles as long as electricity is not produced from renewable resources. Even if this resulted in zero local emissions, it would

Threshold values in mg/km	Petrol	Diesel
Nitrogen oxide	60	80
Particulate matter	4,5	4,5
Carbon monoxide	1000	500
Hydrocarbons	100	--
thereof non-methane hydrocarbons	68	-
Hydrocarbons plus nitrogen oxides	-	170

Table 1: Threshold values in mg/km

probably not lower carbon emissions and overall pollutant emissions because the combustion process or an equivalent still takes place elsewhere. *Figure 3* gives an overview of the petrol car emissions equivalents of electric vehicles in some countries. The CO_2 emissions of electric vehicle usage are compared with the CO_2 emissions of using a petrol-driven car. For example, in Paraguay, driving an electric vehicle emits as much CO_2 emissions as a petrol-driven car with a fuel consumption of 1.1 litres per 100 kilometres. The results show that use of electric vehicles has potential to reduce the CO_2 emissions of the transport sector only in countries with low CO_2 emissions of energy supply, such as Iceland, Brazil or France. [12]

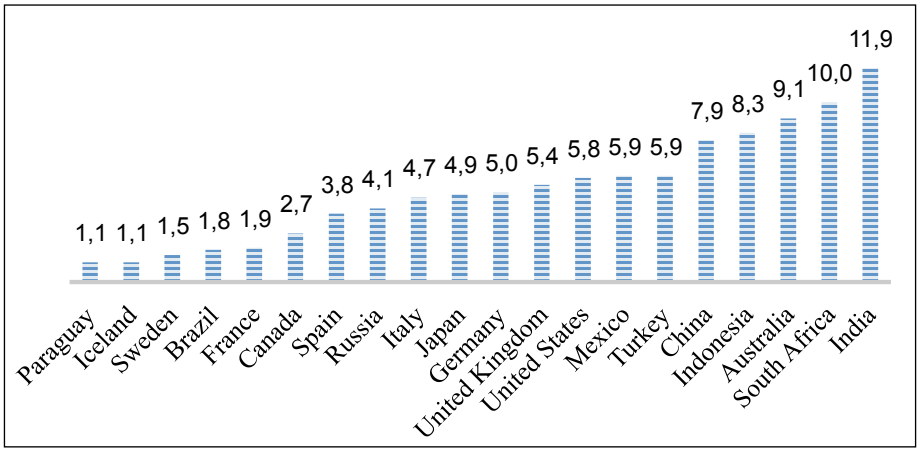

Figure 3: Petrol car emissions equivalent

Source: [12], p.13

There are lessons to be learned from environmental and climate policies and regulations in the car market. First, all of the players in the market have to recognise that vehicle use causes external costs for society. These costs are caused by pollutant and CO_2 emissions, among other factors. Car users, car manufacturers and politicians are requested to face this social burden. Economists argue that external costs should be internalised by appropriate regulation. Otherwise, the market players will not make efficient decisions. From this point of view, political actions aimed at the efficient utilisation of natural resources are justified.

Second, environmental and climate policies pursue different objectives. While air pollution affects the local environment and population, greenhouse gases affect global climate change. Even if a global harmonisation of environmental and climate standards made sense from the industrial point of view, there could be different regional political priorities. In the past, these differences have led to lax inquiry into real-life pollutant emissions in the EU while US environmental authorities were already testing those emissions.

Third, environmental and climate policies must go hand in hand. Therefore, the technological trade-offs between environmental and climate regulations have to be acknowledged by all parties. Otherwise, gains in climate policies may be achieved at the expense of environmental policies. The new testing procedure of the EU type approval is a step towards enhancing transparency of real-life emissions. This is also necessary in order to stress the political priorities. Because air pollutants and CO_2 emissions have a negative effect at different regional levels, it is also a matter of political responsibility not to position global climate change as against local environmental protection.

Fourth, climate policies require a broad global change in energy systems. The implication is that the whole energy supply has to switch from fossil to renewable energy sources, including elements of individual mobility, such as car use. Therefore, a technological change in the transport sector without consequently changing the whole energy supply is not reasonable, which means that the broad use of alternative fuels and/or electric motors will only be efficient if CO_2-neutral production processes are developed and/or the share of renewables in the energy mix is extended. Otherwise, replacing a technology that causes external costs by another one causing similar external costs is not an efficient use of limited resources. ■

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Photo: Ponraj Krish/pixabay

Energy-efficient two-wheelers in Southeast Asia

Policy options for transformational change of two-wheeler mobility in Malaysia

Two-wheeler, energy efficiency, climate change mitigation, transport, electric two-wheeler

Based on an ASEAN-German Technical Cooperation Project, a programmatic approach to making the land transport sector in Malaysia more sustainable has been developed. It focuses on the motorised two-wheeler (2W) fleet. The uptake of electric 2Ws and the introduction of fuel economy policies for conventional 2Ws are discussed. The proposed policy framework aims to facilitate the transformation of 2W mobility in Malaysia and evaluate the potential environmental benefits.

Authors: Friedel Sehlleier, Julia Nagel, Rico Krueger

Motorised two-wheelers (2Ws) are an omnipresent transport mode in Malaysia and across Southeast Asia. Malaysia has the world's third highest density of motorcycles after Taiwan and Vietnam (*figure 1*), with one motorcycle for every three people.

2W-use has been booming in the region, as 2Ws are relatively inexpensive to obtain and operate. In addition, they offer door-to-door mobility and easy parking. They are agile in congested conditions, and improve mobility for low- and medium-income populations in particular. 2Ws often fill the gaps in urban transport systems or even form a part of it, e.g. motorcycle taxis in Thailand or Indonesia. They are also used for commercial deliveries and for public services, e.g. the local police ride motorcycles. In Malaysia, strong growth in population and per capita income has coincided with a 50 % increase in 2Ws over the past ten years. Every year, about half a million 2Ws are registered.

Given their sheer number in the region (see *table 1*), 2Ws contribute significantly to the negative external effects of transport activities, such as carbon emissions, air pollution and its related health impacts, unpleasant odours, noise and road accidents. From an environmental perspective, however, they receive comparatively little attention by policymakers, who often tend to perceive 2Ws as a transitional mode on the way to automobiles. Yet, Malaysia is a case in point, since growing car use does not necessarily replace 2W motorisation. Both car and 2W ownership have consistently grown since 2004 (*figure 2*). 2Ws are the most overlooked transport mode in current government plans across the region to cut transport fuel consumption and carbon emissions across the region.

While 2Ws are generally much more fuel-efficient than cars, they nonetheless offer considerable potential to reduce greenhouse gas emissions (GHG) and air pollution. Not only need conventional 2Ws with internal combustion engines (C2Ws) become more efficient, but also the adoption of electric 2Ws (E2Ws) technology needs to be accelerated and mainstreamed across Southeast Asia. This follows from the growing recognition that long-term decarbonisation goals can only be met by a shift to electric mobility.

In Malaysia, the transport sector is responsible for 26 % of energy-related CO_2 emissions. 85 % of these emissions are from the road transport sector, of which 11 % are caused by 2Ws.

In 2014, almost 12 million 2Ws were registered in Malaysia, accounting for 48 % of all local motor vehicles. The Malaysian 2W market is dominated by relatively low-powered vehicles, with 100 to 125 cc single cylinder 4-stroke engines and a median age of six to ten years. E2Ws remain a niche product in Malaysia today, with approximately 1,000 motorcycles and scooters registered in 2015. However, the government's Electric Mobility Blueprint plans expand the use of E2Ws, with a goal of selling 100,000 units by 2020.

Depending on engine size, the average fuel economy of C2Ws in Malaysia is between 45 and 55 km/l. Compared to the average fuel economy of most cars, which amount to 10 to 15 km/l, C2Ws fare better. However, experts estimate that efficiency can easily be increased by more than 50% to at least 75 km/l through a combination of cost-efficient technologies available today (see *table 2*). Even higher gains (up to 100 km/l) are considered possible by implementing technology improvements such as downsizing engines. Most of these modifications are not significantly expensive; in fact, some reduce the cost by reducing the amount of material required to produce an ultimately smaller and lighter vehicle.

There are currently no mandatory fuel efficiency standards for 2Ws in Malaysia or any other ASEAN country, which would promote the adoption of fuel-efficient technologies by manufacturers. China and Taiwan, both countries with high 2W motorisation, have introduced such standards. Malaysia is eradicating its fuel subsidies, yet the low oil price makes consumers less interested in more efficient models. Despite the currently low oil prices, the cost of fuel is expected to rise considerably in the future due to increasing demand and limited supply. Eventually the operational cost of even smaller 2Ws will become a major customer consideration.

With E2Ws towards a more energy-efficient transport sector

While the efficiency of C2Ws can be greatly improved, from a certain point the ultimate way to improve efficiency further and to eliminate local air pollution will be through E2Ws. E2Ws generally appear in three distinct forms: pedelecs (pedal-assisted; top speed of 25 km/h), e-bikes (no pedal-assistance needed; top speed of 25–50 km/h), and e-scooters (no pedal-assistance needed; top speed above 50 km/h).

For individual road transportation, E2Ws are the most energy-efficient powered vehicles. As electric motors are more efficient than internal combustion engines, studies

Figure 1: Motorised two-wheelers are omnipresent on Southeast Asia's roads.
Photo: Hajo Steinsträßer/pixelio.de

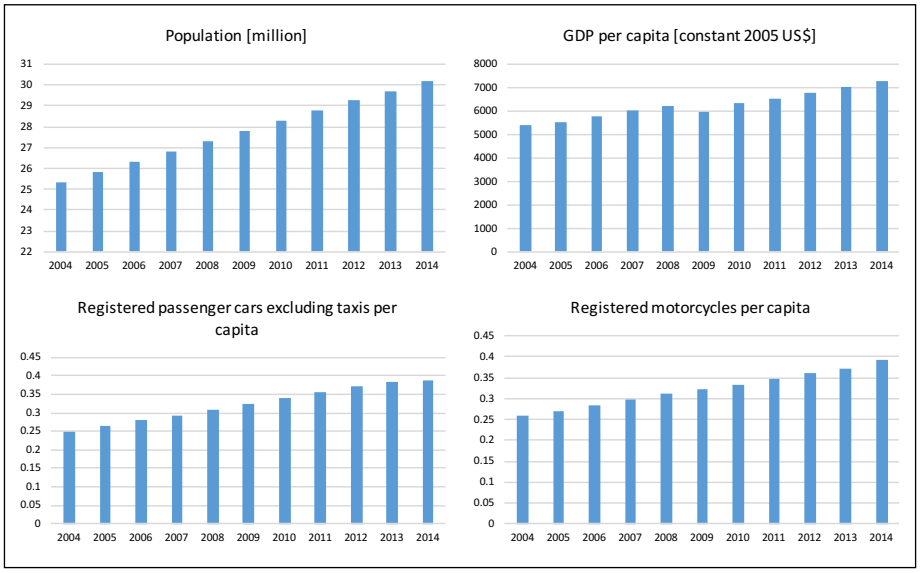

Figure 2: Development and mobility indicators for Malaysia from 2004 to 2014 Source: [1]

Indicator	Malaysia	Indonesia	Philippines	Thailand (2013)	Vietnam (2012)
Population [million]	30.2	252.8	100.1	67.2	90.7
GDP per capita [2005 US$]	7304.1	1865.9	1649.4	3451.3	1077.9
CO_2 emissions per capita (2011) [metric tons]	7.8	2.3	0.9	4.6	2.0
Ownership rate of passenger cars	0.390	0.048	0.009	0.194	0.008
Ownership rate of motorcycles	0.393	0.366	0.042	0.298	0.416
Share of registered vehicles which are 2-wheelers	0.481	0.820	0.553	0.596	0.958

Table 1: Development and mobility indicators of Malaysia and four selected ASEAN countries for 2014 (if not specified otherwise)

2W technology option	Efficiency improvement
Injection system	10 %
Start-stop system	4 % (up to 10 % in cities)
Optimisation of combustion	12 %
Low-resistance tires	5 %
Chassis weight reduction	6 %
Aerodynamic optimisation	7.5 % (up to 15 % at high speeds)

Table 2: 2W technologies and their fuel efficiency potential Source: [2]

show that tank-to-wheel energy savings of 50–90 % can be achieved. [2] In terms of CO_2-impact, the most commonly sold C2W models in Malaysia emit 48 g of CO_2 per kilometre, whereas E2Ws with a similar performance are estimated to emit just 20 g of CO_2 per kilometre. This shows that E2Ws have significant mitigation potential, even with a relatively fossil fuel-reliant electricity mix (0.741 kg of CO_2/kWh), as is the case in Malaysia.

Furthermore, E2Ws have several other advantages over C2Ws. First, the operation of E2Ws does not produce tailpipe emissions, and second, electric scooters are much quieter than C2Ws. Third, E2Ws may require less maintenance than C2Ws, as electric drivetrain systems are less complex overall and contain fewer moving parts. Besides, E2Ws do not require specialised charging infrastructure as opposed to other electric vehicles, as E2Ws can be charged using conventional electrical sockets in residential or office buildings.

Yet, two major aspects currently hinder a large-scale market uptake of E2Ws. First, E2Ws are still more expensive than C2Ws due to low market penetration rates in Malaysia and the region. Second, the range of E2Ws is lower than that of C2Ws due to their limited battery storage capacity. High-performance lithium-ion batteries can address the consumers' range and performance concerns, but are more expensive than low-performance lead-acid batteries. Despite the costs, E2Ws are steadily growing in popularity. It can be concluded that the reason for purchase is not strictly related to long-term economics, but rather related to the low operating cost and overall convenience of an electric vehicle. As newer generations of these electric 2Ws gain ever more power and speed, safety becomes more of a concern.

Despite potential range limitations most commuters and elderly people could very well meet their mobility needs with the range provided by an average E2W. While the average distance covered by 2Ws in Malaysia is 30 km per day, E2Ws typically offer a range of 20 km to 100 km. By contrast, C2Ws provide a range between 150 and 200 km.

Experiences from China and Taiwan show that favourable local conditions are crucial for mass adoption of E2Ws. On the Chinese mainland, the commercial success of E2Ws has been driven mostly by restrictions on C2W use in cities, combined with exceptions for E2Ws. In Taiwan, subsidies for E2Ws were introduced without concurrent restrictions on C2Ws, which turned out to be insufficient for shifting the market towards more E2Ws. [3]

Policy options for transformational change of 2W mobility in Malaysia

Under the Paris Climate Agreement, Malaysia plans to reduce the CO_2 intensity of its GDP by 35 % until 2030 relative to 2005 levels, increasing to a 45 % reduction, if sufficient international support is available. This commitment is underpinned by the National Policy on Climate Change and the National Green Technology Policy, which have been further operationalised by the Green Technology Master Plan (GTMP) and the Carbon Intensity Reduction Roadmap in 2015, both of which consider mitigation in the 2W sector.

The GTMP includes three strategies for cutting transport sector emissions: public transport upgrades, improvement of fuel quality standards, and electric mobility. For the latter, the Electric Mobility Blueprint has been developed with the objective of transforming Malaysia into an electromobility marketplace with 2,000 electric buses, 100,000 electric cars, 100,000 E2Ws and 125,000 public access charging stations by 2020. The target of 100,000 E2Ws is broken down into 50 % corporate and public fleets, 40 % individual consumers, and 10 % under alternative ownership, e.g. E2W sharing schemes. Furthermore, local manufacturing of energy-efficient and electric 2Ws is promoted through Malaysia's National Automotive Policy (NAP). With customised incentives to attract industry investments, Malaysia aspires to become the regional automotive hub for Energy-Efficient Vehicles (EEV). 80% of the 800,000 2Ws expected to be produced in 2020 shall meet EEV specification(s).

Proposed policy framework

Efficient 2Ws are already considered in national policy strategies in Malaysia, but further steps are necessary for making transformational change work. An integrated policy framework could comprise the following elements:

- *Fuel consumption or CO_2 standards for newly sold C2Ws:* Standards should become more stringent over time and could start from the current specification for EEV defined in Malaysia's NAP.
- *Emission standards for new C2Ws:* With regard to C2Ws, fuel quality standards need to be advanced, as the current standard is only Euro 2, and plans for moving to Euro 3 are behind schedule.
- *Compliance programme to enforce adopted emission standards:* Like most other ASEAN countries, Malaysia currently has no inspection and maintenance programmes for 2Ws. Local pilot projects for emission testing and maintenance facilities could be used to build experience.
- *Shift to electric propulsion:* Such a transition requires a political and economic enabling framework to overcome existing barriers.

As experiences from China and Taiwan have shown, the integrated policy approach should additionally encompass the following elements to support the uptake of E2Ws:

- Traffic-related policies and regulations at city level to incentivise the adoption of low-emission 2Ws, including E2Ws, e.g. environmental zones with restrictions for C2Ws;
- Fiscal and economic instruments to bridge the price difference between E2Ws and C2Ws, e.g. direct subsidies on E2W purchase prices (rebate system), lowering the sales taxes, or adjusting circulation taxes on C2Ws;
- Improve charging infrastructure at the workplace to solve range anxiety for commuters;
- Environmentally sound and eco-friendly life-cycle management for E2W batteries;
- Regulation and standards for E2W design including type approval;
- Improvement of consumer awareness regarding E2W technology and its benefits.

Environmental benefits

The impact of fuel economy standards for C2Ws and the introduction of E2Ws on the CO_2 emissions of the Malaysian 2W sector

are modelled with the following assumptions:

- Population will grow in line with official forecasts, and ownership rates of 2Ws will flatten out at 0.4 2Ws per capita.
- Each 2W is driven 10,000 km annually. To accurately account for the replacement of old 2Ws, a stock turnover rate of 5 % is assumed.
- The baseline fuel consumption of C2Ws is 2.2 l/100km and the resulting baseline emission factor is 48.6 g of CO_2/km for 2015.
- For E2Ws, the emission factor of 20.6 g of CO_2/km is based on the 2015 electricity mix.

To obtain the emissions for any year, the number of 2Ws within each age category is multiplied by the emission factor corresponding to the year when the vehicle first entered the market. These products are calculated for C2Ws and E2Ws and summed across all cohorts. 3 different scenarios are considered:

1. A business-as-usual scenario is set as the baseline.
2. Under the E2W-only scenario, sales targets for E2Ws are set. The assumed number of operating E2Ws is 100,000 by 2020 and 800,000 by 2030.
3. The third scenario additionally assumes that fuel economy standards are in place, and fuel efficiency of C2Ws is expected to improve by 5 % annually from 2018 onwards, so that in 2030, one C2W will consume 1.13 l of fuel per 100 km.

Results are presented in *Figure 3*. By 2030, savings of roughly 2,000 kt of CO_2 are expected under the E2W-only scenario. Due to the large fleet size, the magnitude of savings through more efficient C2W is approximately five times bigger and equals 10,000 kt of CO_2 by 2030. This shows that both conventional and electric 2W technology are essential for decarbonising the sector.

Beyond the potential in Malaysia, another case in point is Indonesia. The Indonesian government has already estimated a technical mitigation potential of 16 Mt of CO_2 in 2030 through E2W introduction. For Thailand, replacing 10% of the current 2W fleet with E2Ws could reduce GHG emissions from the road transport sector by 0.23 to 1.27 Mt of CO_2 each year. Additional gains are possible with C2W technology improvements.

The environmental impact pertaining to the production, use, disposal, and recycling of vehicle batteries, especially lead-acid batteries should not be overlooked. To reduce the detrimental effect of batteries, adequate recycling programmes should be in place. Additional negative environmental impacts could occur when consumers shift from public or non-motorised transport modes to E2Ws. However, the availability of clean and efficient E2Ws could also promote a shift from cars to E2Ws.

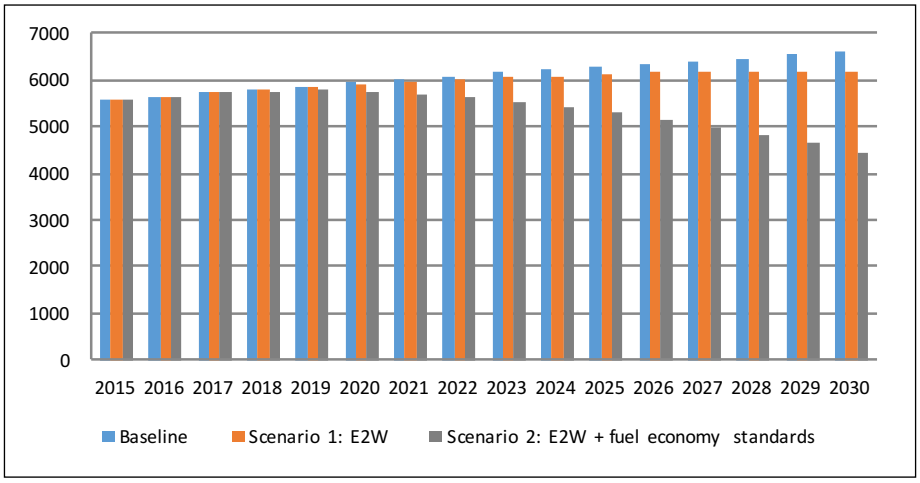

Figure 3: Policy scenario analysis – total annual emissions for different scenarios

Outlook: Potential for energy-efficient 2Ws in Malaysia and ASEAN

Malaysia could take a leading position in 2W efficiency and electrification in the ASEAN region. Its conditions are good due to its various plans to promote energy-efficient and electric vehicle technology and the existing local industry. What was successful in China, and what could become successful in Malaysia, can be replicated and scaled up across the ASEAN region. The regional market potential is enormous since 2W sales in other leading markets like Thailand and Indonesia are around 10 million units per year.

In our opinion, the 2W sector deserves more attention, especially given the climate change mitigation and energy-saving potential, among others. Of course, local conditions, existing policies, rules and regulations across ministries need to be considered and there is no "one-fits-all" approach.

While E2W adoption can be mainstreamed in the long term, conventional 2W technology is likely to remain dominant in the short to medium term. Therefore, the significant potential for improving energy and CO_2 performance of conventional 2W technology also ought to be leveraged. An integrated policy approach is needed including both technology-neutral policies and measures like CO_2 standards and labels for all newly sold 2Ws, and specific actions to help electric 2Ws move out of their niche status. ■

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More information: www.TransportandClimateChange.org

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Photo: Reiner Eidemüller

Cargo bikes – Sustainable logistics in Germany and beyond

Environmental impact, CO_2 emissions, Mikro-Depot, urban freight system

Still common in many places, especially in emerging and developing countries, cargo bikes were long considered inefficient and outdated. However, as urbanization accelerates and transport volumes continue to rise, cargo bikes and smart logistics concepts could be a viable part of the future.

Authors: Kristin Eichwede, Michel Arnd

Today, urban areas are drivers of economic and social development. Continuing urbanization leads to increasing transport volumes, presenting new challenges to urban goods transport[1]. In developing economies, more than 50 % of all city road traffic can be attributed to commercial freight movement[2]. Efficient urban freight systems are considered a prerequisite for urban regions to develop sustainably and stay competitive.[3] Goods transport within cities is often referred to as the "last mile" in the supply chain. Perceived to be most suitable to move goods within the complex urban grid, trucks and vans remain the dominant transport mode. They contribute massively to urban congestion and are often a threat to urban road safety. In addition, trucks have significant environmental impacts such as CO_2, NO_X, particulates (PM10, PM2.5, PM1) and noise emissions.[4]

The transport sector accounts for 28 % of global fossil-fuel-related greenhouse gas (GHG) emissions and is the second largest polluting sector[5]. In 2012, commercial transport contributed 20 % to the total of transport emissions in cities and urban areas[6]. Therefore, promoting and implementing alternative and sustainable urban freight strategies is crucial for balancing the economic growth of cities with social and environmental externalities.[7, 8]

Cargo bikes as a solution

Still common in many places, especially in emerging and developing countries, cargo bikes were long considered inefficient and outdated – and were therefore neglected by planners and decision-makers. However, cargo cycling is in fact a vital part of the transport sector in many places. The UN Economic Commission for Latin America and the Caribbean (ECLAC) and the University of Gothenburg state that for Latin America "cargo bikes could be a viable solution for tackling some of the problems related to contemporary urban transport. From a technical point of view the concept is already feasible, however, since it has never really been considered, the norms or rules regarding the concept are not clear."[9] In Europe, cargo bikes have experienced a revival in recent years, with freelance messengers commonly operating cargo bikes in urban environments[10]. In 2014, the Euro-

pean Cycle Logistics Federation was founded.

Cargo bikes innovation

In light of the expected increase of urban freight volumes, many German authorities have set up measures to increase the share of cycling in urban freight. Logistics is an important part of the *German National Sustainability Strategy*[11] and sustainability, in turn, plays a vital role within the *German National Logistics Strategy*[12]. The state of Baden-Württemberg states in its cycling strategy that 5 % of deliveries within cities shall be done using cargo bikes by 2020.[13] The authorities in Munich support companies acquiring electric cargo bikes with up to 25 % of the cost resp. 1,000 EUR[14]. The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) commissioned the DLR Institute of Transport Research to set up a study on the use of cargo bikes for urban logistics called "Ich ersetze ein Auto" ("I replace a car"). Technological developments, especially electric-power assisted systems, enable cargo bikes to carry greater loads and cover larger distances.[15]

Aside from the big players, logistics start-ups have found new innovative business opportunities. For instance, the start-up Velogista offers same-day goods delivery of up to 250 kg and one Euro-pallet, using electric cargo bikes (*Figure 1*). It offers cargo bike hire including a driver on an hourly basis (28 EUR/h) or an on-route delivery (4.50 EUR per stop). With its own hub in the center of Berlin, it can also deliver parcels and smaller goods as well as allow for permanent rerouting and flexibly accept new orders thanks to the use of smartphones.

For the founder of Velogista, Martin Seißler, goods delivery per bike has several advantages: "We don't need to pay for petrol, insurance taxes are lower, and the expenses for vehicle repair are very cheap compared to vans." Set-up as a social business and cooperative, Velogista aims to pay fair wages and provide good working conditions. However, Mr. Seißler points out that he cannot compete with sub-subcontractors of DHL and other global delivery companies that "take only 80 cents per parcel". Therefore, Velogista concentrates on business delivery for small merchants or organic vegetable box schemes, unless somebody wants to hire a full bike for some hours.

In contrast, the end-customer is at the core of the business for the online marketplace Kiezkaufhaus in Wiesbaden near Frankfurt (*Figure 2*). On an online platform, Kiezkaufhaus enables users to pick goods from local stores and get their purchases delivered the same day, transported by cargo e-bikes. The shops pack shopping bags and hand them over to the drivers, who then deliver them. Items ordered before 2 pm arrive the same day, and Kiezkaufhaus charges 5 EUR per order, independently of how many shops are included. For customers this combines the convenience of online shopping with the benefits of supporting local, independent merchants. The service convincingly combines social and regional components with ecological considerations and an individual service concept that is tailored to individual users. The incorporation of small and micro-suppliers, personal advisors and local vendors helps to reinforce local value chains.

Both concepts, the Kiezkaufhaus and Velogista, show the potential of cargo bike logistics to boost local retail and reduce unnecessary CO_2 emission from transport; inner city traffic is reduced and the region benefits from commerce tax. The start-ups show the great innovation potential of cycling logistics. However, they also only focus on direct delivery within one region. Considering the large quantities of parcel deliveries by larger carriers, cities need to push ahead with solutions to implement sustainable delivery. Examples include services like GNEWT in London and La Petite Reine in Paris. The Austrian city of Graz even uses cargo bikes even for street cleaning[16].

A pilot project of the city of Hamburg and UPS has been in place since February 2015 and is aimed to test the effectiveness of Mikro-Depots and freight delivery by bike or on foot over a two-year period[17]. Mikro-Depots have developed as an innovative answer to ever increasing air- and noise-quality problems arising from goods deliveries in inner urban areas. The depots are usually containers, as is the case in Hamburg, but can also be commercial vehicles or suitable properties that act as an interim storage facility. A container holding up to 400 deliveries is therefore dropped off to a predefined location from which CEP services (Courier, Express and Parcel) then distribute their deliveries onwards on cargo bikes, e-bikes or by foot. In the evening, the container is returned to a larger logistic/distribution center and restocked for the next day.

Due to the success of the first Mikro-Depot at Neuer Wall in Hamburg, particularly in terms of reduced noise and air pollution, three more stations are planned. The last-mile delivery solution consisting of cargo bikes in combination with Mikro-Depots is furthermore planned to be extended to Paris in the first half of 2016[18].

IN BRIEF

Advancement and obstacles for cargo bikes in urban freight

Key hurdles
- General lack of recognition of the positive impact of cargo bikes by the general public or government
- Sector is very informal, reforms might be difficult and require a huge need for stakeholder interaction between the private and public sector
- Lack of Mikro-Depots and infrastructure such as appropriate bike lanes, slow-speed zones and bicycle parking

Key potentials
- Low operating cost (inexpensive insurance and easier vehicle repair, no petrol cost)
- Great flexibility and agility, smart and quick rerouting
- New business models, also for small companies, e.g. Kiezkaufhaus
- Common in many places and existing good practice and proven technical concepts
- Range is extended by electric support

UPS estimates that their solution saves approximately 500 stops of a diesel car that arise from the constant stop-and-go of inner-city traffic and thus presents an attractive alternative for the French capital, where air quality and congestion become growing concerns (*Figure 3*).

To further increase effectiveness in reducing inner-city traffic, Mikro-Depots could be shared by different providers. Delivery could be done by vehicles that serve certain areas and would carry parcels of various parcel companies.

Figure 1: Velogista offers cargo bike hire including a driver on an hourly basis.
Photo: Velogista

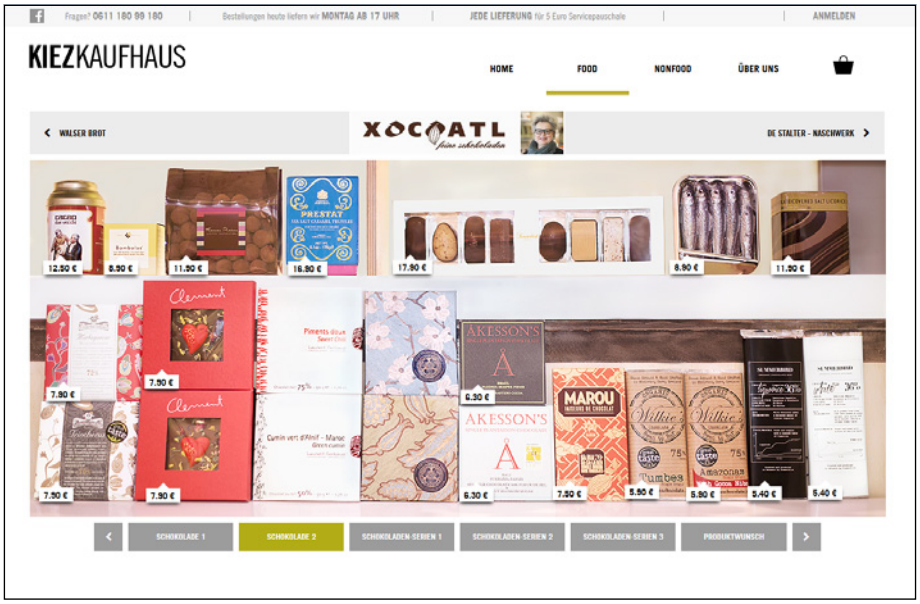

Figure 2: The Kiezkaufhaus online marketplace

Screenshot: Kiezkaufhaus

Cargo bikes in emerging and developing economies

Whereas sustainable logistics and urban freight concepts are gaining more attention in the cities of developed countries, these are still in their infant stages in developing nations. However, there is an urgent need for efficient urban freight systems in developing countries as a prerequisite step for sustainable urban and regional development.

In many places, the urban logistics sector is dominated by informality and "single owner – single store issues", making it difficult to reform the sector[19]. Hagen et al. emphasize in their study on Rio de Janeiro that cargo bike concepts are widely used. Survey respondents see advantages for using bicycles instead of motorcycles and vans in agility (44 %), freight carrying capacity (24 %), cost (24 %) and environmental benefits (8 %). Hagen et al. conclude that "the most important perceived advantage is the ability to quickly deliver products with cargo bikes, and that environmental benefits are a low priority"[20]. For Rio de Janeiro, the authors attest cargo bikes an enormous role in the local economy. They appear to be crucial to the existence of the businesses themselves, as many small businesses would not be viable without this transport mode. However, a general lack of recognition by the general public or government of the important contribution to economic activity, urban ecology and livability is a great obstacle for cargo bike logistics.

To foster the share of cargo bikes in modal split, Hagen et al. suggest increasing support for infrastructure as well as campaigns to improve road safety and comfort for cyclists through urban design strategies which encourage cycling.[21] Additionally, sustainable urban freight concepts successfully implemented in European cities carry potential that could be replicated in developing economies. In many ways, governments in developing and emerging countries can draw from existing experiences and lessons learnt in order to avoid costly mistakes when setting urban freight policy objectives. As sustainable freight solutions such as cargo bikes are not new in Latin America or Asia, particularly in the lower income segments of society, they offer great potential.[22]

Figure 3: A pilot project in Hamburg has been in place since February 2015.

Photo: Flor!an/wikipedia.de

Potential of cargo bikes for sustainable logistics

Key factors to facilitate the development of sustainable urban freight in Latin America are presented by a study of Wilmsmeier, Johansson and Jallow (2015). These include the establishment of public-private partnerships, as well as city-logistics plans to bring urban freight to the forefront of discussions around urban development. Although urban freight, in contrast to public transport, is predominantly controlled by the private sector, stakeholder interaction between the private and public sectors as well as academics and non-governmental players has to be fostered. While cargo bikes might be much more widespread in the context of the local economy, they lack support by the general public and government.

However, considering global warming, pollution and increasing awareness of the need to tackle congestion, the ecological and economic advantages of cargo bikes are part of a convincing solution for a sustainable future. Pilot projects and innovative ideas like Kiezkaufhaus and Velogista integrate well with the existing cargo bike scene. They exemplify new business models that can contribute to a trend towards sustainable logistics, in which cargo bikes play an important role as progressive solutions. Overall, such business models can help to make the general public or governments more aware of the important contribution of cargo bikes to economic activity, urban ecology and livability. Lastly, pilot projects such as the Mikro-Depot concept in Hamburg are needed alongside suitable logistics infrastructure. Investments in suitable bike lanes and slow-speed zones, as well as appropriate bicycle parking are measures governments

FACTS AND FIGURES

About the German Partnership for Sustainable Mobility

The German Partnership for Sustainable Mobility (GPSM) serves as a guide for sustainable mobility and green logistics solutions from Germany. As a platform of more than 130 stakeholders, the GPSM supports the transformation towards sustainability in developing and emerging countries.

Friends of the German Partnership for Sustainable Mobility (GPSM) working on logistics are:

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- Hamburg Port Authority | http://www.hamburg-port-authority.de/en/Seiten/Startseite.aspx
- hinterher.com | http://www.hinterher.com
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- VCD | http://www.vcd.org/
- Verband Deutscher Verkehrsunternehmen e. V. (VDV) | http://www.vdv.de/
- Velogista | http://velogista.de/

could take to increase the share of cargo bikes – in developing and emerging countries as well as in advanced economies. Educational campaigns could focus on cargo bikes in order to improve their conduct in the streets and their perception by the public.[23] If strong and effective policies and regulations are implemented, the subsequent efficient urban freight system can help to support sustainable urbanization and growth in advanced economies as well as developing countries ■.

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Providing solutions to air quality challenges

German Partnership for Sustainable Mobility as a solutions network

German cities mostly benefit from a high level of air quality. Transport is one of the main reasons for air pollution. Therefore sustainable transport measures can significantly reduce the concentration of air pollutants. In the last 20 years, Germany has successfully reduced air pollution, making it an example worthwhile to study. German knowledge and expertise in sustainable mobility solutions are collected in the GPSM network. It can therefore be seen as a pool for solutions that German knowledge and expertise provide to air quality problems.

According to the World Health Organization (WHO), about 3.7 million premature deaths were caused by outdoor air pollution worldwide in 2012. The health risk of air pollution presents a global challenge.

Air pollutants such as particulate matter and nitrogen dioxide have highly devastating effects on human health. Germany has achieved a considerable reduction of air pollution in recent decades, based on technological developments and effective air quality policies. In the last 20 years, Germany has reduced carbon monoxide by 90 percent, polycyclic aromatic hydrocarbons by 90 percent, benzene by 95 percent, nitrogen oxides by 90 percent and particulate matter by 70 percent.

Air pollution is mainly caused by transport, industry, agriculture and energy consumption. Clean Air policies therefore need too be based on a comprehensive approach that aligns all interests in this field. As air pollution is a trans-border problem, international cooperation is also indispensable.

Sustainable transport measures can significantly reduce the concentration of air pollutants, even if emission reduction is not the primary target. These include measures such as public transport improvements and vehicle upgrades, the implementation of pedestrian zones as well as bike and car sharing systems. In addition to that, innovative logistics concepts as well as vehicle technologies can reduce emissions.

The friends of GPSM provide services in different sectors that can help to address the extensive air quality challenge. Some of our friends' expertise is outlined in the following.

German Partnership for Sustainable Mobility
Sustainable Mobility – Made in Germany

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BREEZE

Small-scale, inexpensive sensors and a central Cloud platform

The German start-up Breeze has developed a new form of air quality monitoring for cities: Small-scale, inexpensive sensors and a central Cloud platform form the backbone of their innovative solution.

Most cities in- and outside of the European Union are already required by law or policy to measure urban air quality levels. The same data can also be a valuable source of information about the current state and healthiness of the city, as well as a baseline to measure the success of policy changes.

The hitherto widely applied "traditional" approach of using large-scale and expensive monitoring stations generates too little data to be useful in most analysts' scenarios. Breeze is a German start-up company that leverages the combination of inexpensive, small-scale sensors and a Cloud application based on Big Data and machine learning that allows the generation of a larger amount of high quality data. The sensor itself is "dumb"; it sends its measurements via WiFi, GSM or another data transmission standard directly to the Breeze Cloud. There, the data is evaluated using knowledge of the sensor's location, the local weather and other influences, as well as other sensors' data and external data points ("Breeze Adaptive Cloud Calibration"). Sensors can also be installed on buses or trams to cover a larger area. Visualization and integration capabilities complement the pure data access. While the data is not as accurate as measurements collected by the traditional monitoring equipment, environmental scientists agree that the benefits of the larger amount of data points outweigh a decrease in accuracy.

A potentially huge amount of data points also allows to start differentiation between different emission sources, for instance from transportation, heating or natural sources. Cities could profit from this tool by conducting "urban experiments"; by measuring the effects of policy changes against existing air pollution baselines so that only those with a positive impact will be made permanent. Multiple cities using the same set of indicators might even profit from additional knowledge transfer processes and identified best practices. Finally, as the data would already be easily accessible via standardized APIs, other types of integration and data publication for citizen engagement and involvement would also be very easy.

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A tree and Internet-of-Things technology for clean air

Green City Solutions addresses the global problem of air pollution by combining a special, vertically installed moss culture with Internet-of-Things (IoT) technology. Its product, called the "CityTree", is a freestanding unit measuring 4 m in height, 3 m in width and 0.6 m in depth. It combines special moss cultures with vascular plants that eat particulate matter (PM), nitrogen dioxide and ozone – offsetting 240 t of CO_2e/year in total. Annually the plant filter compensates pollution from up to 417 cars and can be adapted to any environment. The construction contains sensors collecting environmental and climatic data to regulate and control the unit and ensure that the plants survive. Thus, the CityTree has the same effect as 275 urban trees, but requires 99 % less space. Thanks to solar panels and rain water retention systems, the unit requires only a few hours of maintenance per year. By using technologies like WiFi, iBeacon, NFC and digital screens, CityTrees can also transmit digital and visual information.

The CityTree has been implemented in several cities with permanent installations in Oslo (Norway), Dresden and Klingenthal (both Germany) as well as Hong Kong (upcoming in June 2016). Its mobile and freestanding design also made it possible to

Photo: Oslophototour/CityTree Oslo

WiFi hotspot. The campaign has gained national TV coverage and international social media engagement, and over a six months period more than 2,500 people had daily visual contact with the CityTree. The City Council of Oslo decided to invest in the green solution as a part of its urban development program, contributing to the protection of the environment and nature, increasing the biodiversity of the urban environment and educating people about the issue of air pollution and its negative impact on health.

deploy the plant filter temporarily at a number of conferences, fairs and campaigns in Munich, Berlin, Hanover, Halle, Dresden and Jena.

One of the first units sold has been bought by Germany's biggest health insurance company for the purpose of outdoor advertising by using the CityTree as a free

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Modelling air pollutant concentration levels

Quantifying emissions is essential for reporting and for impact assessments of different air quality strategies. To protect human health and the environment, it is important to know the pollution concentrations people and the environment are exposed to. Emissions affect these concentration levels, but they also strongly depend on meteorological and environmental conditions. Both these factors determine the transmission, i.e. the transport and possible transformation of substances, from the emission sources to the receptors. Measurements and modelling are used to quantify these concentration levels, which are regulated by limit values.

Measurements of pollutant concentrations are expensive and time-consuming, hence monitoring stations are typically set up for single locations, not across entire areas or cities. In addition, since measuring is possible only for existing situations, it cannot be used to assess future scenarios.

Dispersion modelling, on the other hand, does not have these limitations and can deliver assessments for entire areas in high spatial resolution as well as for future developments. Based on emission data, dispersion modelling simulates the physical and chemical transport and transformation processes and calculates concentration levels for freely selectable locations and points in time. Depending on the aim of the modelling study and its spatial scope, different models or combinations thereof are employed. Operational modelling systems exist for all relevant spatial scales, ranging from continents or countries (e.g. RCG) down to specific street sections or crossroads (e.g. IMMIS), and are being routinely used by universities and private environmental consulting companies.

For example, so-called screening-models (such as IMMISluft) allow the identification of highly affected areas or "hot spots" and can assess the population's exposure for entire cities. A complete modelling chain with RCG and IMMIS has been applied (for example in Berlin). Such an exhaustive assessment is a valuable basis for air quality planning and prioritising measures (see www.stadtentwicklung.berlin.de/umwelt/luftqualitaet/de/luftreinhalteplan/download.shtml, in German)

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Figure 1: Light-rail corridor fitted into the existing tree-lined boulevard
Visualization: Canberra Metro

Deutsche Bahn in Down Under

The role of DB Engineering & Consulting in the Canberra light rail project

Public transport, public-private partnership, tramway, infrastructure

DB Engineering & Consulting, formerly DB International, has been involved in small projects in Australia for roughly one and a half years. In February 2016, the international planning and consultancy company of DB AG and its local partners were awarded a contract for a light rail project in Canberra, the capital of Australia. In addition to the planning and construction of the 12-kilometer-long line, the main focus is on operation and maintenance over the tendered period of 20 years.

Author: Robert Wagner

The idea of a rail line through the heart of the Australian capital, Canberra, is not new: Already the city planner and architect Walter Burley Griffin, who planned the city from scratch in 1912, envisioned a public rail system. He reserved adequate space in the middle of the arterial roads so that the rail system could be added at a later time. His declared goal at the time was to plan the perfect city of the future, which, in his opinion, included an efficient local rail system.

Exactly 100 years later, in 2012, the ruling labor party of the time made the construction of a light rail system a campaign promise and was confirmed in office. Equipped with this mandate, an inter-municipal association was founded and commissioned with the planning of the project in preparation for tendering. Following this, the Capital Metro Agency assumed its work on behalf of the provincial government and developed a project framework, which was approved by the government in September 2014. Shortly after, potential bidder consortia were requested to register for the tender.

From the initial expression of interest to the awarding of the contract

The business model developed by the Capital Metro Agency is based on a public-private partnership (PPP) approach that allows the relatively small Australian Capital Territory (ACT) to build the first light rail line in Canberra without having to make a large initial investment. To keep the tendering costs low for the industry, the process started with a shortlisting phase. During this phase, only a few tender details were made available, and the documents to be submitted by the applicants focused less on technical solutions than on the ability to implement the project.

Four consortia participated in this shortlisting phase, the two best of which were permitted to take part in the actual tendering process.

Figure 2: Light rail operating on Northborne Avenue

Visualization: Canberra Metro

a) ACTivate Consortium (including Keolis Downer, Downer EDI Works and Bombardier, among others)
b) Canberra Metro Consortium (including John Holland, Pacific Partnerships, CAF, DB International (DB Engineering & Consulting since April 2016) and Leighton Contractors, among others)

After the two preferred bidders were announced in March 2015, the actual tender preparation phase began. The Canberra Metro Consortium divided the overall project into two sub-projects: The Design & Construction (D&C) team focused on preparing the documents required for the planning and construction of the line, stops, depot and all related components. The Operation & Maintenance (O&M) team was responsible for the planning and operation phase. To ensure the necessary coordination between the two teams, the Canberra Metro Consortium worked together at the same location. By consulting with each other on a regular basis, the O&M and D&C teams refined the final designs developed by the inter-municipal association Capital Metro Agency.

A large team of experts from all consortium partners worked on preparing the technical and financial aspects of the tender up to the submission date in October 2015. The biggest challenge was to develop a solution that was not only technically and architecturally appealing, but also functional, cost-effective and hence competitive, as well as taking care to integrate existing green areas as shown in *figure 1*.

In August 2015, the consortium presented the financiers of the PPP project their "light" construction drawings in order to have the planning approved and secure funding. In the final step, the financing costs were incorporated into the final tender and submitted to the Capital Metro Agency. In its final presentation in mid-October 2015 in Canberra, the consortium made its case for the chosen technical approach and its own expertise.

Following a thorough evaluation of both tenders, it was announced in a press conference in Canberra on February 1, 2016, that Canberra Metro had been chosen as the winner of the tender. Since then, both parties have been working on the final contractual details. The contract is scheduled to be signed at the end of May. Construction is to start as early as the end of June to ensure that operation can commence in the second half of 2018.

The project – background information and facts about the light rail line in Canberra

In the UK and America, a distinction is made between tram and light rail: Tram corresponds most closely to what is known in Germany as the "Straßenbahn", which shares its space with other road users such as cars and pedestrians. In contrast, a light rail system normally has a separate infrastructure, which allows for higher speeds and safer operation. Due to the presence of the reserved corridors, Canberra made the right decision to opt for the light rail system. A large section of the line will run down the center of Northborne Avenue arterial road (see *figure 2*).

The two-year construction phase is to begin in June 2016. Operation is to start in the fourth quarter of 2018 – initially for 20 years, but with the option for an additional five years.

If one considers the current situation in Canberra, numerous arguments can be made in favor of the light rail project. Currently, public transport only accounts for a very small part of the overall traffic volume. Even at peak times the outdated buses with their unappealing timetables are hardly operating to capacity. Private transport, on the other hand, enjoys great popularity. Based on this fact, the Capital Metro Authority formulated the main objective of the project: The light rail system is to encourage inhabitants to leave the car at home more often and instead use the public transport system. In addition to revitalizing the inner city and reducing CO_2 emissions, the main objective is to attract investments in the largely run-down buildings along Northborne Avenue.

Another argument: The city is growing relatively quickly at a rate of 3% per year. While there are about 390,000 people living in the capital today, in 2050 there will be about 600,000. To avoid a daily traffic chaos – as it occurs 300 km away in Sydney – from the outset, an efficient public transport system is required.

In the last phase of the project, the 12-kilometer-long line is to connect the rapidly growing Gungahlin suburb with Canberra's city center in 24 minutes (*figure 3*). Twelve Urbos 100 vehicles of the Spanish manufacturer CAT will operate during peak times every six minutes between the 13 stops. Two backup vehicles will ensure the necessary operational flexibility. The 33-meter-long trains with 66 seats can trans-

port up to 207 passengers each, and Canberra's enthusiastic cyclists have also been taken into account: Four bicycle spaces per train as well as bicycle stands at the most important stations are part of the concept, which is supposed to encourage Canberra's inhabitants to switch to using the public transport system. A unique feature will be various paintjobs – depending on the current season – to promote special events such as the tulip blooming season (see *figure 4*).

In the near future, the line is to be extended by 3.2 kilometers and connect the city center with Russel, Canberra's office and business district. This option was a requirement of the initial tender. Another option is the extension to Canberra's airport, which is about three kilometers away from Russel. Furthermore, a triangular route is to link Russel with the government district in the south via the city center. The Capital Metro Agency is convinced that only a single network consisting of multiple lines can be operated efficiently, and that therefore the extensions need to be realized as soon as possible after the completion of the first phase.

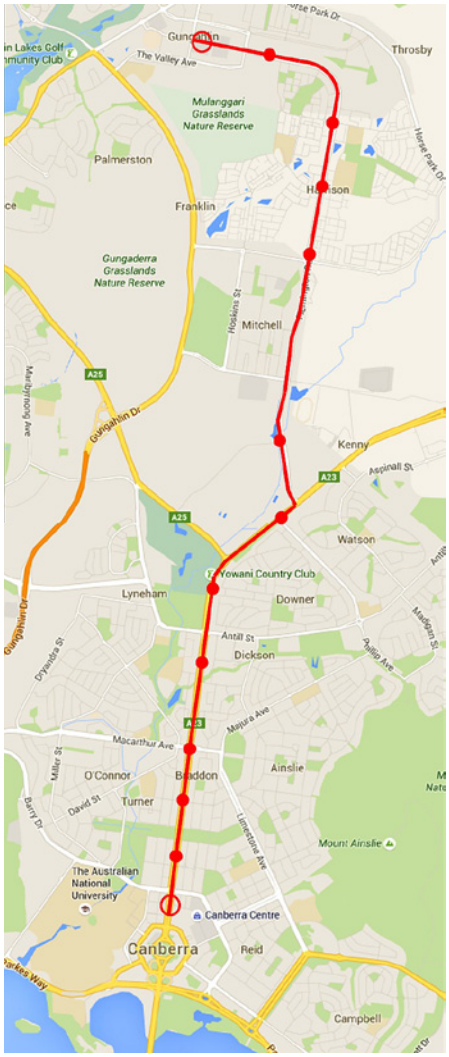

Figure 3: Route map and stop location from Gungahlin at the north to Alinga Street in the Canberra city center

Source: R. Wagner/Google Maps

Figure 4: CAF vehicle with seasonal paintjob Visualization: Canberra Metro

Role of DB Engineering & Consulting and outlook

The DB Engineering & Consulting team, formerly DB International, has been at the side of John Holland and the other consortium partners right from the beginning of the shortlisting phase. After the announcement of the success of this first phase, a team consisting of eight experts was put together, which contributed significantly to the preparation of the tender in both the D&C and O&M teams. Of particular interest was DB Engineering & Consulting's expertise in planning and operating light rail systems, since the other partners only had limited experience in this area.

In addition to the direct employees of DB Engineering & Consulting, a DB Arriva operations manager in charge of operating Stockholm's light rail system traveled regularly to Sydney to contribute his practical experience. In addition, various experts based in Germany contributed to the project, especially with regards to the development of timetables, turnaround cycles and shift plans.

Now that it has been announced that the Canberra Metro Consortium won the tender, preparations are underway to implement the project. DB Engineering & Consulting will serve as the key partner for the Operation / Maintenance joint venture consisting of John Holland and Pacific Partnerships. The main objective is to ensure that the operating expertise of DB Group is incorporated in the joint venture as early as possible to lay the foundation for safe and reliable operation. To ensure this, a small team on site and in Germany will monitor the construction drawings phase from the start of the construction phase in June 2016 and propose changes where necessary. DB experts will also assist the O&M joint venture in obtaining the necessary safety certifications.

For the DB team, the really critical phase will begin with the preparation for operation, which is scheduled for July 2018. Numerous management positions at the operator joint venture are to be filled, at least temporarily, by DB employees to ensure a smooth start of operations and subsequent knowledge transfer over the first few years. Driver training and vehicle acceptance are only two examples of the extensive responsibilities that DB will assume during this phase.

There may even be further opportunities for DB Group to get involved in Australia in the future: The existing bus network in Canberra will have to be adapted to the new conditions to ensure that certain routes do not compete with the new light rail lines, but rather serve as feeder lines, and that convenient connections encourage passengers to start using the public transport system again. Even a potential takeover of bus operations from the current state operator has been discussed. Canberra is not the only city in Australia that is planning such a privatization of operator services in public transport – plenty of potential for DB to expand its commitment in Down Under. ■

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Bangkok's Purple Line on the way

Standard system solution for complete planning of rolling stock and staff

The new metro line in Bangkok opens in just a few months' time. The first test trains have been running on the Purple Line since December 2015. Furthermore, the operating company, Bangkok Expressway and Metro Public Company Limited (BEM), started planning the required resources in April to ensure that everything will run smoothly when the first passengers board one of the modern trains in August 2016. To this end, they are using the integrated standard system IVU.rail from Berlin-based IT specialist IVU Traffic Technologies AG.

IVU and BEM are long-standing partners. The Bangkok-based metro company has been performing all planning processes for the Blue Line, Bangkok's first metro service, with the IVU system since back in 2003, now it is going on with the complete planning for the Purple Line (*figure 1*).

Extensive infrastructure programme

The line was built from scratch in the last few years. It is part of an extensive infrastructure project with which the Thai capital is overhauling its public transport system. Designed as an elevated railway system, the metro will link Bang Yai in the north-west of Bangkok with Tao Poon station in the centre when it officially opens on 12 August 2016. A total of 16 stations serve the 23-kilometre route.

There are already plans in place to expand the Purple Line further. In December 2015, the Thai government approved construction of a 19.8-kilometre extension southwards, serving a further 16 stations. A new 27-kilometre section of the Blue Line is currently under construction. This will join up the existing line to form a closed loop. Completion is planned for 2019. Two monorail lines are also to be opened the year after, followed by a further metro line – the Orange Line – in 2022.

Integrated planning system

IVU.rail ensures lean processes and efficient planning of all transport operations on the Purple Line and the Blue Line and has a modular structure that enables BEM to keep its workflow entirely digital. For instance, the network and timetable can be planned jointly in the planning module of the IVU solution. The system maps the routes between the network points down to the last detail and takes into account attributes such as the expected passenger volume.

To ensure optimum connection of the train control systems used, IVU.rail has various interfaces. The system supplies the trains on the Purple Line, which are controlled using the Bombardier Cityflo 650 system, via the data exchange format RailML. For the trains on the Blue Line, there is a proprietary interface to Siemens VICOS. In both cases, IVU.rail provides regular export of the essential timetable data for signalling.

In addition, all timetable data is automatically available to the schedule and staff-roster planning modules in IVU.rail. To simplify processes, BEM can store all existing statutory and operational requirements directly in the system by means of a flexible rule editor. On the basis of these rules, IVU.rail suggests duties and vehicle schedules and calculates changes of direction, empty runs and maintenance times, ensuring optimum use of all resources.

Expansion options

BEM also has the option of using further modules from IVU.rail, including staff dispatching. The dispatchers use the solution to define weekly schedules and personnel rosters for the train staff, to assign employees to duties and to approve holidays. The software assists them with intelligent suggestions for balanced, rule-compliant working hours for the employees. As well as improving employee satisfaction, this also makes the planning process much more streamlined.

Staff dispatching can also be enhanced by a mobile employee portal that allows drivers to conveniently view duty schedules and submit duty or holiday requests online – a key element in keeping workflows lean and making life easier for dispatchers in a growing company.

With the modular structure of IVU.rail, these enhancements can easily be implemented in the existing configuration. In this way, with the software solution from Berlin, BEM is ideally equipped for possible future line expansions resulting from the ongoing extension of the Bangkok metro network. ■

www.ivu.com

Figure 1: IVU Traffic Technologies AG delivers its standard solution IVU.rail for all planning processes for the new Purple Line in Bangkok
Source: BEM

Intelligent management of traffic congestion

Intelligent traffic cones for automatic recording and dissemination of information regarding traffic backlogs

Traffic impairments, infrastructure to vehicles, Cloud-based traffic information

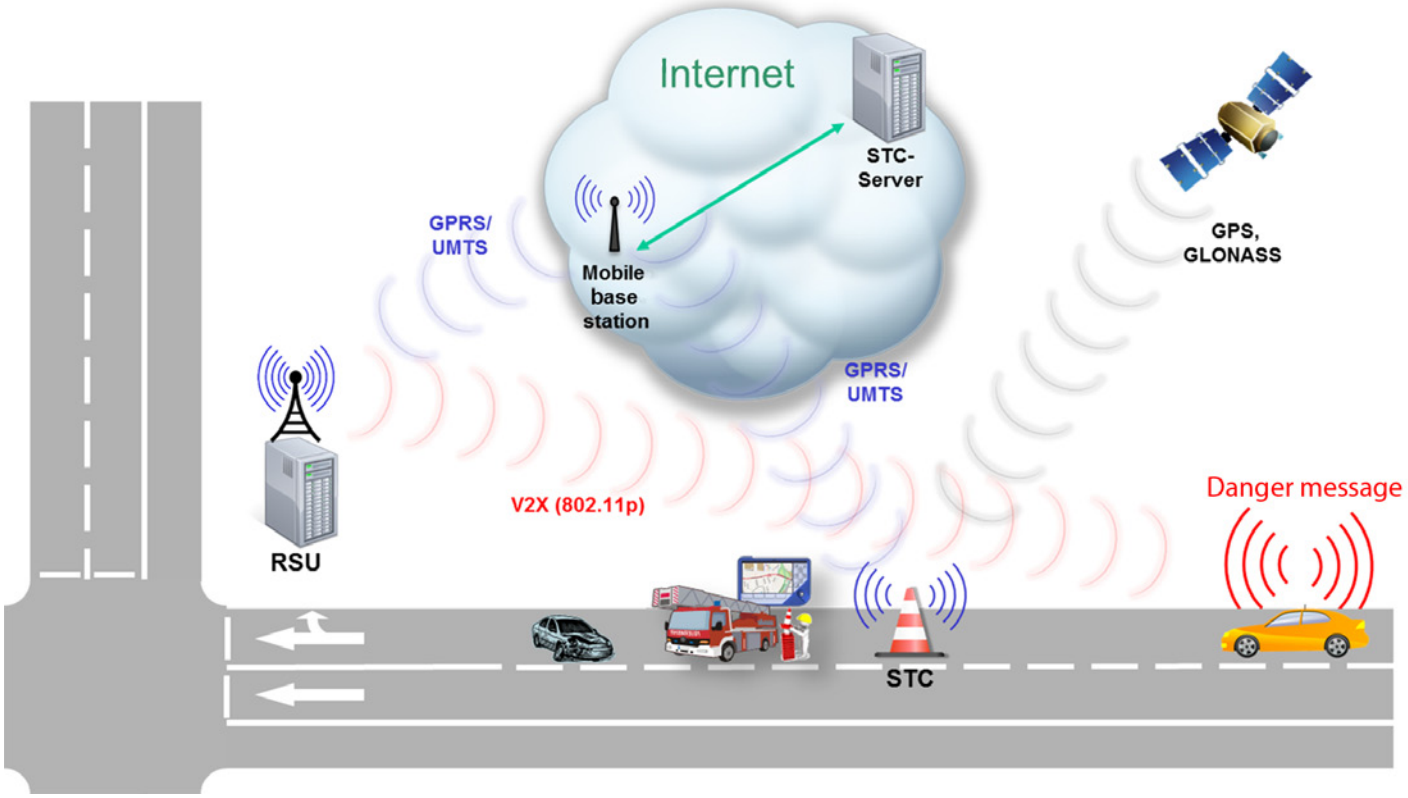
Sudden disturbances on roads and in intersection areas can lead to massive traffic impairments and to potentially dangerous accident situations. In the future, the use of intelligent traffic cones could help here: They serve as a safeguard and as recording devices for disturbances and promptly deliver situation-relevant information including precise location data. The smooth dissemination of information supports the rapid dissolution of traffic backlogs and gets traffic flowing again.

Authors: Joachim Schade, René Schönrock

Traffic impairments that disturb the normal traffic routine always carry a high risk of accidents. These disruptive traffic impairments can have multiple causes. While planned roadworks and abnormal loads represent obstacles that can be predicted in advance, other impairments such as accidents, neglected vehicles and items, mowing work and breakdowns as well as unplanned or mobile roadworks are unpredictable and often lead to substantial disturbances of the traffic.

In order to prevent these impairments from becoming a danger for traffic participants, the affected trouble spots have to be marked and, if possible, cordoned off immediately and sufficiently and all road users in the vicinity must be informed of the disturbance.

For ensuring safety at accident scenes as well as roadworks, red-white painted barrels and tons were used in Germany until 1952. However, these safety measures in themselves represented a potential cause for accidents, especially because of the heavy weight of the blockade barrel. With the invention of the traffic cone made of rubber and functioning as a barrier item and also as a road sign, the potential accident risk has



Figures: ifak

Figure 1: The intelligent traffic cone concept

Figure 2: Top view of an intelligent traffic cone with integrated circuit board

been substantially reduced. This device can be used at short notice to efficiently warn road users of danger spots and to mark the scenes of accidents and interventions. White cross stripes on an orange basis increase visibility and thus the warning effect.

However, these warning devices of traffic disturbances are only perceivable for road users who are directly at the place of the accident or the roadwork site. Currently, it is still impossible to pass on information on short-term traffic congestion in real time and/or directly to other traffic participants. For these situations, the smart traffic cone, developed by the ifak Institute in Magdeburg, will provide relief in the future.

With the smart traffic cone (STC), a world-first safety feature has been invented. This traffic cone guarantees the prompt recording and dissemination of information about disturbances in traffic, including precise location data. The uses of the traffic cone are versatile: It is a *tool for police, rescue services, salvage and service staff*, who can embed it into their working routine (*Figure 1*).

The smart traffic cone contains multiple electronic modules for geolocation and communication, allowing an independent, highly precise localization (*Figure 2*). Through the use of methods like Precision Point Positioning (PPP) and Differential GPS (DGPS), noticeably higher precision than with normal GPS can be reached, so that the cone can be localized on a digital map down to line precision.

Other features such as the automatic determination of the length of a disturbance through digital networking of several smart traffic cones are enabled by Cloud-based traffic cone management. The collected data on impaired and blocked sections are compiled, processed and passed on to the internal headquarters as well as connected platforms via mobile and wireless systems. In addition, a connection to the public platform *Mobilitäts Daten Marktplatz* (MDM, www.mdm-portal.de) has been realised by ifak. This enables traffic participants to retrieve information about disturbances on their route even over long distances in real time, by calling up time-critical data via the Internet, radio (TMC), DAB, navigation systems or future advanced direct driver assistance systems. The traffic cone itself becomes a part of the digital infrastructure of the Mobilitäts Daten Marktplatz as a data supplier and as such supports independently the efficient data and information stream to the data users.

However, also in the direct surroundings of an impaired and blocked area, the road users can profit from the information sent by the smart traffic cone. Car2X technologies provide them with important news in real time. Information about disturbances is passed on directly per dedicated short range communication (DSRC Radio) to approaching vehicles and thus extends the user's view of the upcoming road section. Through the early recognition of disturbances and the fast reaction of the traffic participants, traffic safety can be considerably increased.

With the dissemination of information both via the MDM platform and via direct wireless connection to other vehicles, the road users can adapt their routes and driving manner to the latest traffic situation and, depending on the overall situation, bypass disturbances or blocked sections. ■

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Industrial intent platforms for Logistics 4.0

Logistics industry, process chains, value creation, networks, networking

The vision of Industrie 4.0 confronts the logistics sector with new challenges – although topics such as networking and digitized process chains that follow the "Smart Factory" pattern are in fact well-known themes. Yet, in the face of exponentially growing volumes of data and the rising number of players in global supply chains, a rethink is required. Conventional management methods and systems are reaching their limits. But how to exploit the potential of digitalization in a targeted way to develop internationally competitive business models within logistics?

Author: Christian Krüger

The German Federal government's recommendations for implementation of Industrie 4.0, which has been officially declared a matter for top-level politics, clearly state: "In Industrie 4.0, business and engineering processes are dynamic in character, meaning that production processes can be modified at short notice and respond flexibly to equipment failures or other disruptive events, caused by suppliers for example."[1] But without seamless digitalization of supply chains, none of this will succeed.

Industry or politics – who is driving the process?

Could politics be the real driver here? IT firms such as SAP, Telekom and Bosch are probably better placed than the world of politics to develop a robust business model. In the USA, the scene is dominated by the international Industrial Internet Consortium (IIC), whose members include IBM, Microsoft and Cisco, among others. But besides these companies, there are already innovative medium-sized enterprises that are systematically exploiting the opportunities of digitalization and are offering tools for the networking of companies in spite or maybe even because of the lack of standards. The goal is always to network the logistics systems in a more intelligent manner as an integral component of all value creation steps and to eliminate system boundaries. These networking platforms have the potential to make disruptive change in the logistics industry. Today's planning processes, still mostly organized manually and based on the laborious exchange of information by telephone, fax and e-mail, will either disappear or be pushed to the margins.

Towards Industrie 4.0 with industrial Internet platforms

So how can the entire logistics process be digitized with the ultimate aim of implementing automated communication that spans multiple companies and is at the same time immune against errors? In the past, the generally chosen route was to link companies via bilateral interfaces. In today's conditions, this is no longer appropriate since the lengthy implementation time and the huge effort entailed by this method negatively impact the flexible networking of enterprises. Moreover, there is a constant need for updating the interfaces. All this represents a substantial obstacle to the prompt networking of enterprises in a business relationship, especially in case of ad-hoc relationships.

This is why the economy needs open industrial Internet platforms with which dynamic and complex business networks can be flexibly established and controlled. This will allow the flexible interlinking of different services so that every participant is supplied with all the necessary information (e.g. order status) at all times. In addition to order details and checklists this includes status information for preceding and subsequent steps. The innovation: New standards can be configured online at any time and system updates leading to unproductive downtimes are a thing of the past. Users benefit in multiple ways:

- The IT effort for interfaces drops drastically.
- Process transparency rises throughout the entire process chain; order status is visible for any participant with the appropriate privileges.
- The effort involved in data capture is reduced, errors are avoided.
- Data is available in real time.
- Resource deployment can be planned and controlled more efficiently.
- The administrative effort is significantly reduced.
- Ad-hoc as well as long-standing business relationships are equally supported.

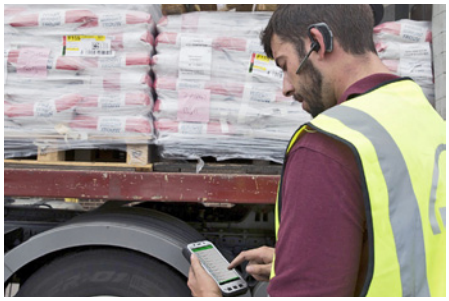
While the focus of Web 2.0 was on private Internet users and their networking by Social Media and B2C solutions, platforms in the B2B field provide effective and convenient support for the networking of business processes in collaborative economic structures.

What will be the impact on staff?

Industrie 4.0 is also bringing drastic changes to working environments. The range of communication channels being used is shifting from telephone, fax and e-mail to structured order communication via platforms. In planning and scheduling this means a focus on order execution monitoring and control centers and the disappearance of the shift handover book and the sticky yellow note. Individual members of staff will profit from a reduced workload thanks to the use of ergonomic cockpits displaying job functionality, planning diagrams and controller dashboards.

Employees working outside the office will receive their daily tasks with all job details electronically via smartphone or tablet and report the progress of work back in the same way. Thus work processes are integrated between all companies and individuals involved and of course also the machines. The platform concept makes it easy to include information accompanying an order such as matching of services provided, photos, status reports, GPS tracking or capture

The use of Web browsers or apps makes it easy for any user to actively participate



Data can be captured and reported at the point of origin in real time

The availability status of all resources is visualized on the job monitor

All photos: catkin GmbH

of mobile working hours. This will not only facilitate scheduling/job allocation, but also make the work of quality assurance and accounting departments significantly easier.

There are scenarios for application in practically every sector. The itinerary of a container shipment from Asia to an end-customer in Europe, for example, involves inputs from shipping agents, freight forwarders, container terminals, shipping lines and rail and road haulers. The result of the all-embracing transport management will be a significant acceleration of the administrative and hence also physical throughput times, cost reductions for all parties, plus considerable gains in transparency and quality. To this end, it is not imperative that any and all enterprises should take part from the outset. Even with only two partners involved, the effect already becomes noticeable. Similar scenarios can be observed in the field of facilities management, maintenance/industrial services, the energy sector and many more.

Industrial Internet – for everyone?

Everyone involved should feel the benefit of these platforms. It is therefore important to prevent entry barriers. Success comes when every party concerned can take an active part in the simplest possible way via the Web and apps. Small enterprises and freelancers use browsers and apps, companies with an extensive IT landscape integrate their systems step-by-step via the open platform specification. In addition, the in-house ERP system can be supplemented with mobile apps for the company's employees.

Digitizing staff deployment

The key objective is to network the company and any mobile staff throughout the order execution process. The advantages are obvious in comparison to the dilemma of conventional staff deployment planning. Every day, transport and logistics service providers in particular are faced with enormous documentation efforts as well as time-consuming planning and coordination processes. In addition there is the risk of errors. Systematic staff planning for order execution, the integration of temporary and agency staff and a coordinated control of the company's permanent mobile resources can only be implemented with a great deal of effort.

In contrast, modern platforms following the Logistics 4.0 concept provide simple and secure support for data reporting at the point of origin in real time. For this purpose, apps must be robustly designed to prevent errors and disruption. This will make communication and coordination problems, which are typical of collaborative processes, a thing of the past. All information relevant to the current process step is displayed in a clear manner on the job monitor. In parallel, the scheduler receives instructions on the deployment or availability status of all resources on employee and machine level. Planning errors are avoided and idle time is reduced.

Summary and outlook

Modern industrial Internet platforms create the conditions for simple, clearly structured and secure communication across the entire order management process and are thus particularly suited to logistics. They enable transparency and improve the exchange of information throughout the logistics network. Media discontinuities are cleared by this type of "central interface" so that transport jobs can be handled more efficiently between all participants. The error rate drops significantly and process costs are demonstrably reduced. An authentication procedure ensures that process information is only made available to the defined authorized parties in the chain.

In the coming decade, the number of platforms will grow considerably, the number of platform users even more so. With networking via platforms, Internet and apps, transparency in logistics processes will become the norm. Already today there are clear indications that the technological developments in the scope of the development of Industrie 4.0 will bring disruptive change to the entire logistics sector. Opportunities are arising for new business models, while conventional business models must either be quickly adapted or will be reduced to filling niches. The control of logistics processes can be partly automated, and scheduling departments will have more time available to devote to core tasks and management of non-standard events and processes.

Where will we be in 10 years' time?

If industry and industrial equipment and machines become increasingly networked and "smart", then logistics within and between the value creation stages must reach a new information level. The traditional freight forwarder as a provider of transport and a data entry services will increasingly become a manager of complex processes. Thus logistics in an industrial value creation chain must become even smarter and more digitally networked than today. The enabling technologies are available and ready to deploy – now we need bold decision makers who recognize the opportunities of digitalization and want to actively shape this development. They will be rewarded by enormous gains, both qualitative and financial. ■

[1] Concluding report of the Industrie 4.0 Working Group: Implementation Recommendations for the Industrie 4.0 Future Project, p.5, April 2013, Eds: Promotorengruppe Kommunikation der Forschungsunion Wirtschaft – Wissenschaft

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Photo: N.Ndadoum

Possibilities and limits of urban transport services in developing countries

The case study of motorcycle taxis and minibuses in N'Djamena, the capital of Chad

N'Djamena (Chad), public transport system, mini-buses and taxi motorbikes

The supply of public transportation in N'djamena is dominated by innumerable private enterprises operating minibuses. The stations, routes and schedules are not fixed. In addition, there is no fixed price, in other words, the fare is bargained. Consequently, these minibuses cannot meet overall transport demand, particularly to the zones of the outskirt quarters. That is why public transportation in N'Djamena is not reliable. Even though taxi motorbikes offer their services to cater for public transportation, some problems such as lack of safety and comfort, derisory price, the absence of reliability, or poor accessibility of some quarters are on the increase. In the light of this, the question is: How can we help the current agents to improve the quality of public transportation services in N'Djamena?

Authors: Nadmian Ndadoum, Doumdé Marambaye, Tatoloum Amane

Several agents are currently implicated in the organization of public transportation in Chad's capital N'Djamena. They have direct or indirect contact with one another. There is a more or less strong network that enables them to negotiate and share ideas so as to make important decisions that would enable them to resolve certain problems that are obstacles to their organization. The interviews conducted and the studies carried out in the field among the agents were used as the basis for a typology of the agents and an inventory of the conflicts between them.

Motivation

Background

Sub-Saharan Africa is increasingly characterized by high population growth rates. Before 1960 no city had a population of one million, but in the mid-1990s, there were

already about 100 cities with a population of 100,000 or more. The last decade saw the birth of a number of million-inhabitant cities such as Lagos, Abidjan, Dakar, Nairobi and Douala. In some countries, this growth has affected the outskirts of the cities, with the birth of several neighborhoods where accessibility is a major challenge for the inhabitants. For them, access to work, education and healthcare is difficult or, given the large distances and the lack of public transport services, limited to the bare minimum (United Nations Organization, The Economic Commission for Africa). The management of urban mobility begins with the management of the occupation of urban space (Aderamo 2012).

Like other African cities, N'Djamena – the capital of Chad close to the Cameroun border (*figure 1*) – does not offer a legal framework of land use for its population, who is constantly in search of new residential areas (Todes 2012). Urban policy is characterized by weak development in spatial and urban transport planning (see Huneke 2007). There were no planning documents for spatial planning until 1996, when a study by the Groupe Huit consultant office set up an Urban Reference Plan (URP). This document, however, lost its reference character because it has not been fully implemented. The objectives attached to it no longer correspond to the current context of the city. It is this concern that in 2008 led to the design and development of a planning framework document for the city of N'Djamena. Over time, the city of N'Djamena began to spread to the west and to the east in concentric waves, with the neighborhoods of Djambagato, Bololo, Klémat and Djamba as starting points (see Jemba, 2012). It covers an area of 20,000 hectares (RGPH2 2009), shown in *figure 2*.

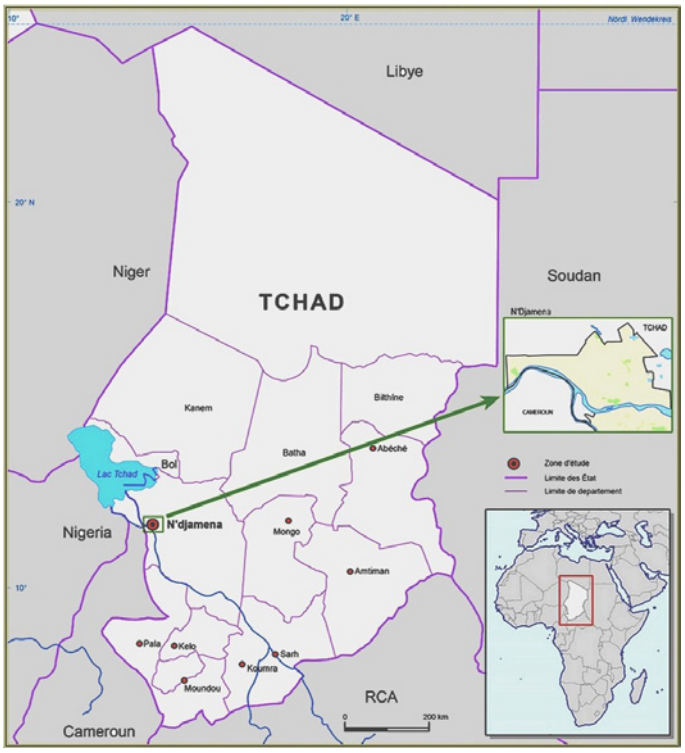

Figure 1: Geographical situation of the study area
Source: FAO 2005, modified by N. Ndadoum

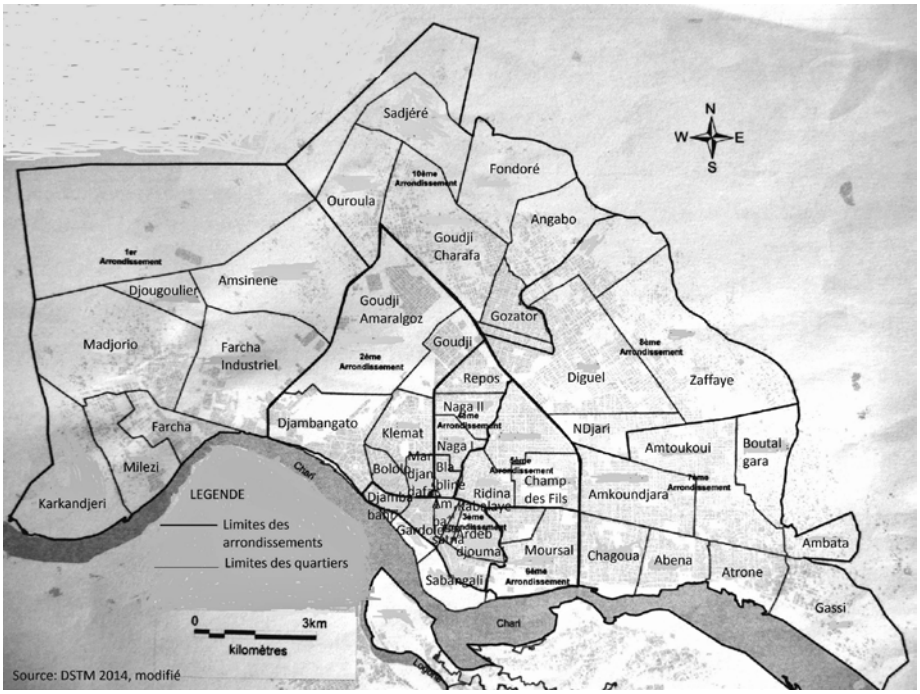

Figure 2: N'Djamena map showing recent quarters
Source: DSTM 2009, modified in 2015 by N. Ndadoum

Urban transportation is definitely an important factor for the smooth operation of cities. It answers to the mobility needs of the people and contributes to spatial integration as well as to quality of life. This is in accordance with a proverb that says: "If a man has found what to eat, it's because his feet made a move". Human activities and movements are inseparable and indispensable. For instance going to work, seeking new employment, going to school or to the university, shopping, participating in a wedding or mourning ceremony etc. However, it is important to integrate the surrounding towns and their inhabitants in the urban lifestyle by providing them with the means to travel in order to create social and geographic links. In N'Djamena, the public transport system is dominated by small private enterprises. The service is however a farce: There are no fixed stopping points, no routes and no schedules, the price is not set and the drivers have little or no training. Using motorcycle taxis has become an alternative means of transportation since 1990. Despite this alternative, the mobility problems mentioned above still remain in place. The following research question comes to mind: How can we improve the quality of public transportation service in N'Djamena in cooperation with the different players?

The objective of this research is to identify the players, to know their roles, their professions as well as their area of interest in the system, and to analyze different points of frictions that they may have.

Interviews

We conducted 46 interviews with motorcycle taxi drivers on the various selected sites. The average length of an interview was

approximately 25 minutes. In order to interview the motorcycle drivers, we went to the sites several times on different days of the week and at different times of the day to better understand the reasons for their choice to work in the morning or in the evening. The field interviews with the drivers were conducted after we had visited the offices of the associations or unions to which they belong. The approval of association or union leaders helps create confidence in the field before the interviews with the drivers. In order to interview the drivers of minibuses we chose 6 routes out of the 16 existing routes. Then we went to the bus stations where we interviewed 4 minibus conductors per station, which makes a total of 24 drivers interviewed.

Figure 3: Dembé market – a trader unloading his goods after using the services of a motorbike taxi
Photo: N. Ndadoum

Obtained results

Typology of drivers of motorbike taxis

Motorcycle taxis drivers have very different work patterns, which vary based on their own schedule.

Drivers operating in the morning and in the afternoon: Depending on other tasks and concerns they may have, the driver choose their work hours in the morning and in the afternoon. They chose the period between 5:00 and 8:00 a.m. and between 12:00 and 14:00 p.m. to operate their service. These hours fall within the morning and afternoon rush hours. Their clients consist of pupils and students, traders and certain civil servants. Indeed, given the unscheduled stoppages of the minibuses and due to the heavy traffic jams in the morning, these customers opt for motorcycle taxis to quickly reach their work places. Many live in the new neighborhoods in the peripherals, which are not easily accessible to the minibuses. These areas are beyond the 1st to the 10th district. For pupils and students, it is the only means of quickly reaching their schools to participate in the early hour courses that start at 7:00 a.m. Similarly it is an easy means for some traders living in the suburbs to quickly get their goods (vegetables, meat, fish) to certain shopping malls and markets, taking advantage in particular of the coolness of the morning (see *figure 3*). The motorcycle taxis allow people living far from the central districts of the city to take an active part in city life and enjoy some advantages offered by the city, namely training, health care and economic activities. Thus through their service, border effects between the suburbs and neighborhoods of the city are erased. Their favorite areas are the neighborhoods of Ambata, or Boutalbagar, Gassi in the 7th district and Madjorio, Milezi in the 1st district.

The areas served by the moto-taxi drivers extend beyond certain localities like Toukra in the 9th district, Goudji Zaffaye in the 8th district, Angabo, Goudji Charafa and Sadjeré, Ouroula in the 10th district to enable some vegetable farmers to transport their products directly to the various markets of the city.

Drivers operating in the evening: Our evening visits to some parking sites enabled us to distinguish another category of motorcycle taxis drivers. These are indeed those who have chosen to work from 4:00 to 6:00 p.m. and sometimes continue up to 8:00 p.m. Unlike those working in the morning and afternoon, for household workers, even those living in the suburbs, there are very few options for transportation. And that despite the important need for mobility between neighborhoods. These movements take place from one suburb to another or from a suburb to an area downtown. Some colleges and vocational training schools created in some of these areas in the last ten years offer courses at night only. The movement of students attending these schools has led to a high demand for motorbike taxi services. It is also in the evening starting at 6:00 p.m. that some traders go back home from the market. At the same time, minibuses start to become rarer after 6:00 p.m. Thus, for traders living in the outskirts of N'Djamena, the only alternative they have is to use the services of a motorbike taxi.

Drivers operating alone: These are the motorcycle taxi drivers who are not registered with any trade union. We approached a few of them to learn about the reasons for their choice to work alone. While for some the existing regulation is not compatible with their interests, for others there is no other reason than the constant search for money. Indeed these drivers are working only occasionally and part-time so it is difficult for them to comply with the rules and principles of the associations. They only work when they need money. The discipline in the stations does not suit their interests. Indeed, in each station, it is the customers who look for drivers, and given the size of the station (with an average of 20 people), it is not always easy to find a customer in need of service. Therefore the probability of making enough money is small. This group of drivers chose to be mobile, i. e. constantly in search of customers. Therefore, they have no fixed territory. They wear a fake vest only to reassure customers willing to seek their service. The regulatory body put in place to control motorcycle taxis five years ago has made wearing a vest compulsory for all motorcycle taxis drivers. This is in accordance with section 16 of the law. In article 13, wearing a fake vest is deemed a serious offence; anyone caught wearing one will pay a fine of 50,000 CFA Francs (FCFA), which corresponds to about 77 EUR. According to the testimony of some conductors belonging to non-official groups, they are very discrete about their activities because they are in constant fear of being identified and denounced by a controller in the field, especially when crossing unknown territory. This group operates in anonymity; however, the unofficial drivers play an important role in the system. Indeed, they are available everywhere, and some customers are lucky enough to have them at their doorpost so as to enjoy their services. They are very flexible with regard to the price.

Typology of minibus drivers

There are three main groups of minibus drivers: The vehicle owners driving their own vehicles; the drivers also recommended by the union; and those who for reasons comparable to those mentioned above for

Figure 4: Motorcycle taxi drivers await customers getting off minibuses as seen in this picture taken at the Globe roundabout in Farcha
Photo: Nadmian Ndadoum

the motorcycle taxi drivers have decided to operate illegally.

Owner-drivers: The owners are those drivers who have chosen to drive their own vehicles. We met at least 7 of them on 6 selected lines to conduct the interviews. They are usually former apprentices or drivers who used to work for others and have now become owners. According to some testimonies, the remuneration received does not allow them to buy a new vehicle after a few years. However thanks to the established savings system through monthly contributions, after 5 to 6 years some were able to afford to buy a used car that cost from 1 to 1,500,000 FCFA (about 2,000 EUR). Owner-drivers take care of some daily routine activities such as small repairs. It is only on board that they are assisted by an apprentice, who collects money from customers having boarded along the way or who gives change to those whose destination comes before the end of the line.

Permanent drivers: The permanent drivers are professional drivers who work all day. They work for minibus owners to earn wages of 4,000 FCFA / day (about 7 EUR) (see Paper II FNSTUIT 2011). The daily turnover to be paid to the operator apart from daily charges such as fuel or fines, amounts to 6,730 FCFA (10 EUR). The income depends in fact on the number of vehicles operating on a specific route. The route records more buses when it is a busy one. This also lessens the chances of a driver to make a lot of money as they have to wait their turn to invite passengers. Some drivers are impatient to wait for their turn; however, they operate in secret by picking-up passengers along the way. This strategy is much applied by some occasional drivers, that is to say those who are not registered to any station. Even though this practice is forbidden, many go in for it to maximize the daily revenue.

Illegal minibus drivers: Illegal drivers are those who do not belong to any union. Several reasons explain the existence of this group in the system. The first reason is the system of loading passengers by turn, which many drivers apparently do not support. It is a system of organizing the loading of vehicles according to their order of entry into the station and their destinations. Given the size of stations, some drivers must wait for several hours to load. In some cases, it is only during rush hours that the buses depart in rapid succession. These times fall within the following hours: 6:00 to 8:00 a.m. and 12:00 to 2:00 p.m. This system has many advantages on the organizational level, but does not allow drivers to attain the daily income they expect and need. This group plays an important role in the system. In the suburbs, some drivers may even go far along the main road to find customers.

Types of conflicts

The main types of recorded conflicts are those between the public authorities and the drivers of minibuses and motorcycle taxis regarding compliance to the legislation; conflicts of competition over passengers between motorcycle taxi drivers and minibus drivers; and finally conflicts between the drivers of motorcycle taxi or minibuses and customers.

Disputes between the government and the drivers of minibuses and motorbikes

In Chad, the government created a Road Traffic Brigade (BCR) within the police, which controls the traffic at crossroads, potential areas of conflict. The difficulty to apply priority at different junctions where there are poor or no traffic signs has led the government to mobilize the BCR to control the traffic. However, the minibus drivers and motorcycle taxis do not often comply with these rules. The desire to achieve a maximum daily revenue especially during rush hours causes them to be impatient and refuse to comply with the guidelines and instructions of BCR officials in some junctions and roundabouts of the city. These offenses are punishable by fines or even confiscation of vehicle documents, especially given that they are the cause of frequent accidents in these locations. For motorbikes, the BCR checks shall be confined to the compulsory use of a helmet, which is governed by the decree No. 26/MTPT/DG/DTS/2002 of the Ministry of Transport. Article 22 on the use of motorcycle taxis sets the fine for failing to helmet at 3,000 CFA francs, or about 5 EUR. The behavior of some motorbike taxi drivers sometimes makes the conflict complicated. They often have clashes with BCR agents when it comes to handing over their bikes. Disputes between the government and the drivers of motorbike taxis and minibuses are due to information breakdown or lack of consultation before drafting any law. Among many examples to illustrate these are the cases of minibus drivers who have raised the price for their service after the decision of the government to reduce the number of seats in the vehicles. This puts them in conflict not only with governments but also with passengers. “The minibus drivers have increased the price without any explanation.” (Abdoulaye Niankounian, the General Adviser of the intra urban union of transport). “The conflict between the government and the minibus drivers and motorcycle taxis finds a solution by improving the living conditions of some drivers. Indeed for some of them, the contract binding them to vehicle owners does not entitle them to a monthly salary. They are generally paid in relation to the revenues of the day. Thus, to overcome these problems, some drivers

engage in behaviors that are often in conflict with current regulations" (Noitora, deputy director general of transport surfaces, oral source, March 14, 2013).

Disputes between drivers of minibuses and motorcycle taxi drivers

The search for the most profitable routes often leads to competition between the drivers of minibus taxis and motorbike taxis. The motorcycle has become an alternative to taxi services in particular because it saves time. It enables its customers regardless of traffic to arrive at their destination at the desired time. In the early 1990s the rivalry between the two means of transport became visible. Especially when some motorbike taxis were roaming on certain minibus routes and offering their services to customers anxious to save time. This is what happens often around the markets and at some places where drivers have to wait their turn. The minibus drivers see the existence of motorcycle taxis drivers as an obstacle to them in terms of revenues. Customers indeed prefer motorcycle taxi service because of better accessibility and availability. Outside of the rush hours between 7:00 a.m. and 4:00 p.m., time to wait for your turn to load at the stations is too long for minibuses. The views of the operators of these two means of transport are increasingly divergent regarding road safety in the city of N'Djamena. Considering the rate of road accidents in N'Djamena, it is often the behavior of one or the other person that is mentioned. Motorcycle taxi drivers are often pointed at by the government as responsible for many road accidents in N'Djamena, especially due to their behavior. Motorcycle taxi drivers rather denounce a lack of responsibility on the part of minibus drivers and the behavior of some officers of BCR as being the source of accidents. The creation of motorcycle taxi drivers' trade unions in various districts in early 2010 coincided with declining tensions between the operators of both means of transport. This is the beginning of a mutual understanding between the motorcycle taxi drivers and minibus drivers. This cooperation is visible in several junctions in the city of N'Djamena (*figure 4*). The complementarity of these places is obvious through its organization. This is what occurs daily in Farcha.

Disputes between the drivers of motorbike taxi and minibuses and their customers

Misunderstandings typically arise because of the transport fare and the destination; this is often a source of conflict between motorcycle taxi drivers and some minibus drivers with customers. Tensions arise between the motorbike taxi driver and his client when the latter has agreed to the price but later changes his mind and wants to pay less than what was originally agreed. It seems to be often the case when drivers are dealing with some crooked or bad customers. After a little dispute and under the threats of the driver in the presence of some passer-by, the customer ends up paying what was originally agreed. Indeed streets and houses in N'Djamena do not have a fixed address. This is what makes it difficult not only for tourists but also for drivers to find their way, but it also renders the situation difficult when the motorcycle taxis are asked to drop their clients at the door. As a motorcycle taxi driver in the 8th district said: "The motorcycle taxi drivers are sometimes aggressive vis-à-vis their clients when the destination is not well understood and they must travel an extra distance to convey the client to the desired place". The clients try to describe the location of house in relation to a known place such as a market, school; hotel, hospital, pub or restaurant. For the minibus customers, conditions are more complicated. They have to inform the driver or his apprentice a few moments before they want to get off so that the driver can start to slow down several meters before the desired location. The passenger simply says stop and at the same time gives a knock on the side wall of the vehicle in such a way that it is loud enough for the driver and the apprentice to hear. In either case (motorcycle taxis and minibuses), "tensions become even more intensive between customers and drivers when it is time to pay the fare, which usually costs 250 or 300 FCFA (0.50 EUR). Sometimes customers take out a bill of 5,000 or 10,000 FCFA (10 or 15 EUR)" (Abdoulaye Adoum, oral source 2013). Still according to the testimony of Abdoulaye Adoum, the Secretary General of the inter- and intra-urban transport union of Chad, some customers take the precaution of informing the driver when they have only a big bill. Then the driver can agree or refuse to take the customer on, depending on the availability of the necessary change.

Conclusion

This work contributes to an understanding of how the agents of public transport in N'Djamena work and allows the authorities to plan and foster a lasting development in this sector. There are so many challenges still facing this sector in the area of informal activities, which are more or less illegal, and the agents form a network that is complex and difficult to operate, which is at the same time the only guarantee to improving the quality of the offer. However, without the knowledge of who these agents are and how they operate, it would be very difficult for the authorities and the agents to communicate, negotiate and share ideas with one another so as to take important decisions and resolve the problems that arise from the operation of this sector. This study does not only open doors to knowing the agents of public transport in N'Djamena, but it also helps us to know how they are organized. This helps the decision makers, policy makers, budget planners, town planners, and investors to take efficient decisions in the scope of public transport in N'Djamena. ■

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Tower Bremen. Photo: DFS

Emotion-sensitive automation of air traffic control

Adapting air traffic control automation to user emotions

ATC, emotions, visualisation, HMIs, automation

A human being is more flexible and adaptive than any technology. Nevertheless, the right support systems at the right time can bring large benefits. But how can we know when someone could benefit from technological support? The StayCentered project is working on the idea of collecting physiological data to assess the mental state of an air traffic controller. Information about the controller's mental state would allow for adaptive assistance and additional measures in cases where work overload is anticipated. Such measures could, for example, limit the number of aircraft in the airspace being controlled or provide relief using adjacent sectors.

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About 28,000 commercial flights are conducted in Europe every day, and air traffic controllers are responsible for providing separation between these flights. Air traffic controllers work in control towers or area control centres. They give instructions to flight crews via radiotelephony to ensure safe flights. While tower controllers generally monitor and coordinate aircraft in the vicinity of the airport with which they have visual contact, area and approach controllers rely on the radar information displayed on their screens (*Figure 1*).

In the past decades there has been a significant increase in the degree of automation used in air traffic control, especially at area control centres. The demands placed on air traffic controllers have been reduced due to a wide range of technology. This includes alerting systems, more reliable predictions of future flight trajectories, the filtered display of only the targets relevant for a certain working position, and the implementation of ergonomic colour concepts to increase awareness. This reduction of workload has led to an increase in airspace capacity and productivity – meaning the number of flight hours that are handled in an air traffic controller hour.

Increasing the degree of automation at controller working positions remains firmly an R&D topic. The planning of implementation focuses primarily on technical issues. Recording the human workload in situ in this increasingly automated system only plays a subsidiary role. New controller assistance systems will lead to adjustments being made to current workload models, such as adjusting the time controllers will spend in position or on breaks when processing a specific airspace. However, they will not

lead to changes to the mechanisms used to reduce workload itself. The same measures based on traffic figures and subjective parameters will continue to be used to modulate the actual workload of air traffic controllers and to reduce their actual workload by coordinating with adjacent sectors. This mechanism is not a closed control loop, particularly because it does not predict the future demands that will be placed on the human operator.

As a counterpoint to this direction, a theory has arisen in which the actual cognitive workload of operators can play a growing role when there is a higher degree of automation. Such knowledge could be used, for example, to trigger a change to the distribution of workload between human being and machine to fit the situation or to trigger a specific type of display. To be able to adapt automation to actual or anticipated requirements, the system needs knowledge of the workload state of the air traffic controller based on relevant, understandable, and minimally invasive measurable indicators. Even more beneficial would be the ability to predict such states reliably for a relevant period of time. This prerequisite cannot be met at the moment. Today, the team determines the level of the air traffic controller's workload. For en-route control, there are always two air traffic controllers simultaneously responsible for a specific airspace. This means they can assess and evaluate each other. At some control centres, it is possible to enter the workload level directly into the ATM system. This informs adjacent teams so that, if required, they can be asked for active support. This is a well-tested procedure but does not necessarily have to remain unchanged in the future.

StayCentered project setup

The StayCentered project at the Technische Universität Chemnitz (sponsored by the German Federal Ministry of Education and Research) is pursuing the goal of collecting and comparing the physiological and cognitive workload of air traffic controllers using various sensory data. The goal is to create a real-time simulation of the controller workload using these data as the basis. Then recommendations should be made as to which actions should be taken or adaptations of the visual display of the interfaces should be made. The project also aims to provide a capacity forecast for sector planning at DFS control centres. On the basis of air situation displays of traffic already handled, recommendations can be made about the need to raise staffing levels, or to temporarily reconfigure airspaces to provide better control, for example of evening air traffic. Furthermore, the two-person team of controllers will be monitored more closely to obtain feedback about what aspects of verbal and non-verbal communication are necessary for the job. Overall, the goal is about optimising working conditions.

A real-time simulation environment of area control working positions was chosen for the study (*Figure 2*). This is located on the premises of the DFS Research and Development Centre in Langen (near Frankfurt, Germany). The simulator is used to validate the research into controller assistance tools (CATO) as part of the SESAR project "Separation Task in En-Route Trajectory based environment" with the involvement of air traffic controllers from the DFS Bremen control centre [2].

The project encompasses the development of a controller assistance system that displays conflict-free flight levels and headings to increase airspace capacity. The simulated traffic scenarios are characterised by a very high traffic density that can lead to air traffic controllers reaching their workload limits. This effect was one of the decisive requirements of the StayCentered project as the system can provide support for just such situations.

Taking measurements in live operations of air traffic control was not considered for a number of reasons, including the fact that it could not be ruled out that controllers would be distracted by the measurement instruments. In addition, it is not legal to record radiotelephony for R&D purposes.

For these reasons, the tests are carried out with simulated air traffic control as previously mentioned. To accomplish this, all the necessary parameters have to be readjusted as precisely as possible. In addition to the air traffic controllers being tested, additional controllers and pilots support the tests by simulating traffic in the adjacent sectors. The traffic scenario was developed by DFS experts and fed into the simulator. Specific conditions such as especially dense traffic situations, emergency situations in the cockpit or flights without flight plan can also be added to the simulation.

The participants in the experiment are always informed about the measurements to be taken and the general context is explained to them. Furthermore, representative bodies, such as the staff council, were included in the planning of the experiments so that the requirements of staff representation could always be complied with.

In addition to measurements taken at the simulator, observation studies are to be carried out during live operations and air traffic controllers will be interviewed and surveyed. These methods are being used to attain two main goals. Firstly, factors will be identified that are different during live operations than in the simulator. Secondly, interviews and questionnaires offer insights into variables that cannot be directly observed but might be stress-inducing for air traffic controllers. A pooling of all the methods is used to analyse the existing systems as well as to estimate the potential of the planned adaptive user interfaces.

Recording relevant parameters

To keep records of the cognitive workload of air traffic controllers, the StayCentered project pursues a comprehensive approach to acquiring data in the simulations. A stereoscopic camera is used to record the posture and movements of the controllers' upper body in three dimensions. This makes it possible to differentiate between relaxed postures and highly concentrated ones. It is also used to determine in which situations controllers use verbal and non-verbal com-

Figure 1: Air traffic controllers in an area control center Photo: DFS

Figure 2: Real-time simulation environment of area control working positions at DFS Research and Development Centre in Langen Photo: DFS

munication to get their message across. By monitoring skin conductance, heart rate and skin temperature, the physiological state in relation to the emotional and cognitive state can be constantly measured. Conclusions can then be drawn about particularly demanding traffic situations as well as phases of underload. In the same way, by recording eye movements, elements are identified that could potentially lead to a critical situation. The dilation of pupils is also an indication of concrete cognitive overload. This is possible due to a pair of eyeglass frames equipped with an integrated frontal camera that records the field of vision as well as an infrared camera inside the frame to record the movement of the eyes. In addition, both radio communication with the pilots and the spoken communication between the two controllers is recorded using a number of independent microphones. The relevant parameters such as pitch, speed of speaking and other characteristics are correlated to the air traffic situation. The movement of the controllers' facial muscles is also recorded and analysed with the help of the facial action coding system (FACS) to determine the controllers' emotions. Specific groups of facial muscles are assigned action units. Specific combinations of these correlate to different basic emotions.

All these data are integrated into an overview by means of sensor data fusion. Various methods are applied to compare the data against each other. This makes it possible for more than one sensor to be used to measure a specific parameter. The additional sensors are intended to confirm the correlation. For example, an increase in skin conductivity may be connected to a change in the duration eyes are fixated on something or to a change in how the person is sitting. The system has many valid indicators that can show that the workload of the controller has increased in this situation. The plausibility of the data supplied by the system is ensured by comparing them with objective traffic data (number of aircraft or aircraft movements in the sector) at the point in time in question. This mechanism allows the system to make projections whether or when a critical situation could arise due to an unfavourable combination of controller emotions and air traffic in the relevant sector. The system then transmits an alert about the critical situation. To create a model for calculating the emotional state and the cognitive workload, the controllers record their own subjective appraisal of how high the level of their workload is, how much pressure they feel, and how good their overview of the air situation is. Both the objectively measured data of the controllers and the flight situation as well as the subjective aspects are used for the creation of a model. This cross-validation increases the reliability of correctly interpreting the data.

Preliminary results

In addition to the data obtained by the measurements during the experiments, further measurements of concentration and performance diagnostics were carried out. These showed that air traffic controllers possess an above-average ability to concentrate and direct their attention. Although these tests were designed and validated to be practically impossible to complete within the allotted time, some of the air traffic controllers as test persons were able to complete the tasks. This shows that normal psychological tests are insufficient to ensure valid recording of the actual abilities of air traffic controllers. New approaches must be developed as most performance tests are designed to diagnose people with "normal" abilities.

In addition to the bodily indicators for stress, other relevant variables were identified in interviews with active air traffic controllers about the general characteristics of their job. The major stressors for air traffic controllers are high traffic volume, particularly with a high number of vertical movements, unexpected events such as aircraft without flight plans entering their sector, or failures and errors of the functionalities of equipment despite good back-up systems. In addition, long periods of absence from the job or other personal factors negatively influence the perception of work overload/performance of controllers.

When it comes to user interfaces, the display of information about the workload of the air traffic controller is very important. This concerns information about the workload situation of controllers in adjacent sectors when high traffic levels make it necessary to shift traffic to these sectors. However, it also concerns the prediction about the controller's own situation as this can be the basis for decisions such as issuing pilots direct routings. Further adaptations in the presentation of information about the controller's situation are necessary as not every piece of information is equally relevant for every situation.

Well-designed user interfaces take into account and reflect the social environment in which they are implemented. They also take into account the existing mental mod-

els of the users, and support their procedures. As cooperation within the team of controllers is essential for air traffic control, all the interfaces the controller uses must also support this cooperation by making actions transparent. In terms of the controller's mental processes, it was determined that the mental representation of the flight situation is not necessarily three-dimensional. As a result, the two-dimensional display has become the preferred way of displaying the air situation. Special attention is paid to altitude information as this has been called the most important piece of information for controllers.

For further discussion of the initial results concerning working methods of air traffic controllers and the implications of these for the emotion model and user interfaces see [1].

Outlook

The project's long-term potential extends far beyond the specific scenario of air traffic control. In fact, it lays a cornerstone for the hypothetical use of assistance systems in many fields where the human factor could potentially be the cause of devastating safety problems. This includes professions such as pilots, train drivers, and even safety staff in nuclear power plants. Although there are detailed provisions and procedures designed to provide maximum safety in these fields, just as there are in air traffic control, not all possibilities can be accounted for, as the human factor is a volatile variable. Assistance systems can provide support when the technology is limited to a minimally invasive level that will not influence actual work processes. In the coming years, solutions can be expected due to the rapid development of technology, particularly in the field of wearable devices that collect physiological data. The major advantage here is that such a system is based on objective indicators, whereas human interpretations regarding one's own cognitive and emotional state are always subjective and, consequently, can be distorted under demanding conditions. An assistance system should be free of such problems such that bad decisions are prevented and critical situations avoided. The real-time collection of video, audio and physiological data of staff raises the question as to how these data should be handled, how to prevent their misuse, as well as data protection in general. The related challenges that need to be met seem small when compared to the benefits such systems could bring. ■

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Multi-objective trajectory optimization

Modern trajectory optimization affects more criteria than fuelburn and time of flight

Air traffic management, trajectory optimization, trajectory assessment, aviation environmental impact, contrails

Today, the air traffic industry is confronted with demands and goals, aiming conflicting optimization criteria. Airlines minimize fuelburn and time of flight, whereas public environmental consciousness increases faster than the technical progress in the reduction of the engine emissions. Furthermore, airlines are facing an increased worldwide demand and an already limited air traffic capacity. Here, the required development and assessment of optimized trajectories with multi-criteria target functions is introduced.

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The air traffic system is faced with many challenges, which are sometimes subject to strong dynamic fluctuations. Beside a growing annual volume of air traffic and a highly competitive and cost-driven market, there is an urgent need for environmentally sustainable transport services. Therewith, air carriers are in many ways restricted in their freedom to operate. That is why the European Commission founded the Single European Sky (SES) program to restructure the European air space with the objective of optimizing air traffic to increase the efficiency of the European air traffic [1]. The Single European Sky ATM Research (SESAR) program has been set up to harmonize the interests of all air traffic stakeholders and develop the implementation of the SES objectives [2], which are aiming to secure a sustainable development of the European air traffic sector. Besides the triplication of capacity, the increase of safety by a factor of 10 and the decrease of air traffic management costs by 50 %, the environmental compatibility of each flight is to be reduced by 10 %.

For these targets, air traffic performance is measured and validated with the help of key performance indicators (KPI) [3], defining special target values of the performance of the air traffic system. The research project MEFUL (Minimizing the emissions in operational flight with guaranteed operational safety as contributing to an environmentally friendly air transport system) of the Chair of Air Transport Technology and Logistics at Technische Universität Dresden develops and applies KPIs considering cost indicators (CI), environmental performance indicators (EPI) and safety perfor-

mance indicators (SPI) for an optimization of the air traffic system from a single trajectory up to a complete airline network using an appropriate weighting. This weighting is realized by translating the EPIs into costs and by complying with all safety regulations. Thereby, optimal trajectories that balance the conflicting goals given by completely different KPIs can be identified.

Even among the EPI there are conflicting objective functions regarding an optimized trajectory. Fuel-driven emissions are minimized at high cruising altitudes (around 12 km altitude, FL 390) and a steep climb gradient, whereas nitric oxide emissions are minimized at lower cruising altitudes (around 9 km altitude, FL 290) and a shallow climb gradient flown with reduced thrust. Furthermore, the ambient atmospheric conditions are strongly influencing the optimization. For example, the formation of condensation trails (contrails) is primarily driven by weather conditions and mostly confined to a small region in the atmosphere, which should be avoided by air traffic. Here, an example of trajectory optimization under realistic weather conditions is shown considering direct operating costs, fuelburn costs and environmental costs including contrail formation.

Trajectory optimization

For trajectory optimization, a flight performance model and a lateral pathfinding algorithm are used iteratively by the simulation environment TOMATO (TOolchain for Multicriteria Aircraft Trajectory Optimization) defining the input parameters for both models and assessing the trajectories regarding the KPIs. The weather scenario used is taken from grib2 (GRIdded Binary) data, provided by the National Weather Service NOAA [4]. *Figure 1* shows the iterative workflow and the interactions between input data, pathfinding module and flight performance model, as well as the trajectory assessment within TOMATO. The input parameters are defined by weather data, city pairs and aircraft type together with information on the airspace structure and cost charges. On this basis, the pathfinding module calculates the lateral trajectory at cruising altitude, considering the global target function of the optimization (e. g. minimum costs). The calculated route, the weather data and the aircraft and engine type is used by COALA to estimate the vertical trajectory considering the given cruising altitude. Additionally, COALA quantifies engine emissions. Using the KPIs, TOMATO calculates the length of time of contrail formation as well as all cost components and evaluates the trajectory. During the next iteration, TOMATO adjusts the input parameters for the pathfinding module and for COALA to iteratively converge to an optimal trajectory.

Trajectory calculation

The vertical trajectory optimization is done by an aircraft performance model COALA (COmpromized Aircraft performance model with Limited Accuracy) for an Airbus A320 aircraft with two CFM56-5A3 engines (111.2 kN, each) based on the integration of the dynamic equation as a result of flight mechanics allowing for the loss of aircraft mass due to fuel flow. Take-off is realized with 100 % thrust, which is reduced after three minutes and followed by a continuous climb operation (cco). The target true air speed at cruising altitude is derived from an extremum estimation of the specific range under consideration of the different boundary conditions (i.e. differences in temperature and density gradient). For descent, continuous descent operations (cdo) with idle thrust and a true air speed for a maximum lift/drag angle during gliding flight are calculated as proposed by Kaiser [5] and Scheiderer [6]. The target functions of true air speed for the different flight phases are used as controlled variable by using a proportional plus integral plus derivative controller (PID controller). Maximum thrust during cruise and climb, the drag coefficient and the fuel flow are calculated using BADA by EUROCONTROL [7]. The trajectories correspond to recommended flight profiles (see ICAO [8]) with a climb gradient of 1,000 feet per nautical mile and a descent gradient in the range of 300 feet per nautical mile. Unsteady flight attitudes are considered during take-off and climb and are optimized with respect to minimum forces of acceleration in the vertical and horizontal direction.

Conditions of contrail formation

Condensation trails are ice particles that develop at flight level from condensed water vapor emitted by the aircraft [9]. The water condenses on soot particles that are also emitted by the aircraft. For contrail formation, the ambient atmosphere has to be cold enough to counterbalance the exhaust heat, which works against condensation. The threshold temperature can be derived from the Schmidt-Appelman criterion [10], [11]. Under these conditions, contrails will live for about 100 s until the complete evaporation of the ice particles [9]. However, in an ice-supersaturated ambient atmosphere (ISS) (that means a relative humidity with respect to ice more than 100 %, which is possible due to missing activated ice nuclei at flight level), contrails will form into long-lived artificial cirrus clouds, which are also called persistent contrails [12].

In the Earth atmosphere energy budget, contrails act like a barrier [13], [14]. They scatter incoming shortwave solar radiation back to the sky and they absorb and re-emit outgoing longwave terrestrial radiation back to the Earth's surface. The contribution of a contrail on this extinction of radiation is called radiative forcing (RF) and measured in watts per square meter [19].

Trajectory assessment

The developed optimization objectives can be grouped into two categories. 1) direct operating and delay costs, and 2) environ-

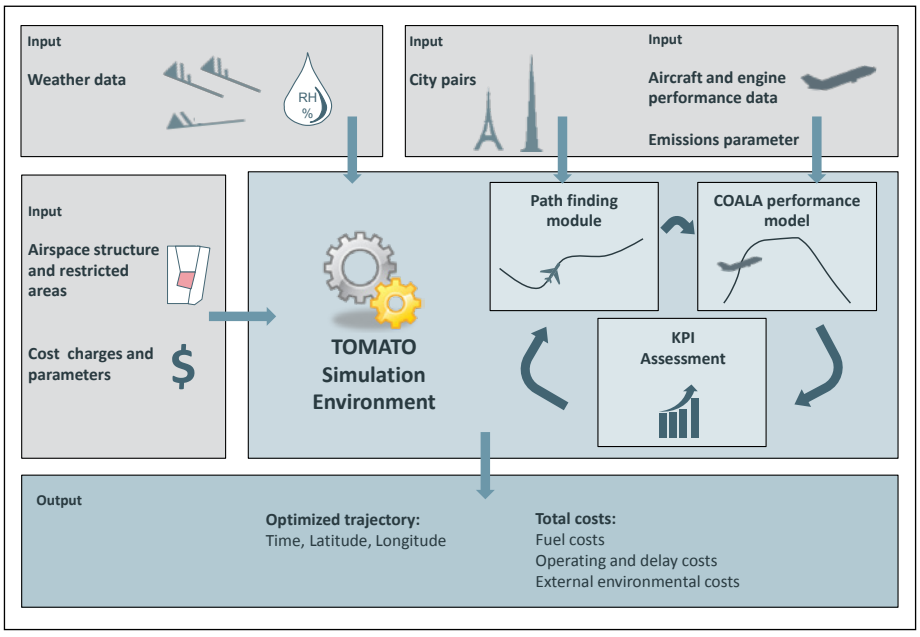

Figure 1: Workflow of trajectory optimization and assessment with TOMATO

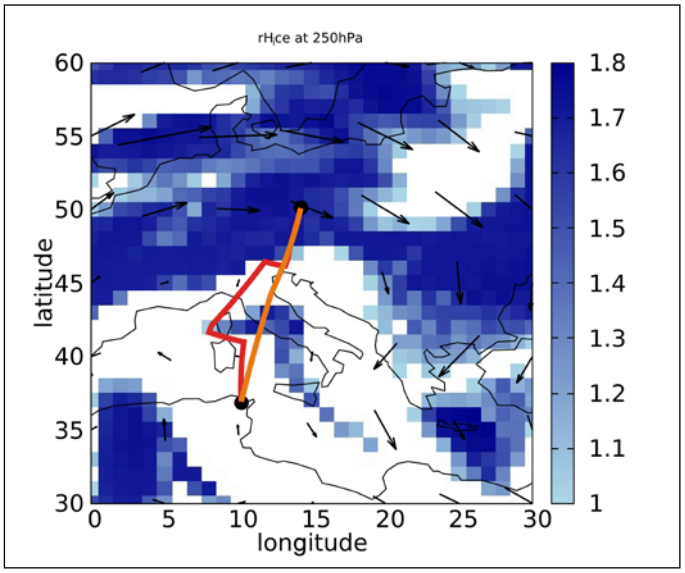

Figure 2: Lateral trajectories in the given weather scenario. Wind speed and direction are indicated by arrows. ISS are shown by blue grid points. Case 5 is shown in red..

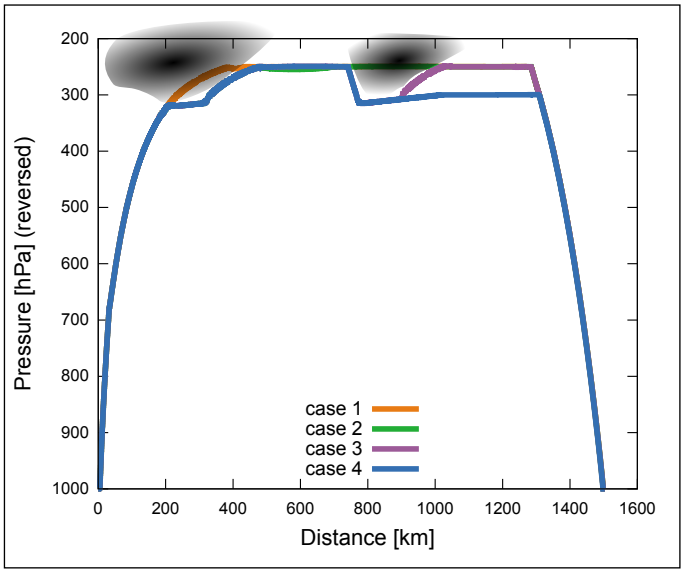

Figure 3: Lateral trajectory optimization (Case 2 to 4) to avoid contrail formation. Case 3 causes minimum total costs.

mental costs due to the environmental impact of engine emissions. Furthermore, costs due to contrail formation will be discussed. The direct operating costs (DOC), i.e. fuelburn, staff and maintenance costs, are used for trajectory optimization since they are clearly linked to a single flight event. Fuel costs make up the biggest share of DOC components, accounting for 25 to 30 % of DOC. Currently, the price of jet fuel is comparatively low and set to EUR 0.39 per kilogram following the average of IATA fuel price monitor for the year 2016 [15].

Staffing costs are time-dependent and also a major constituent of DOC. For each flight crew member, costs of EUR 1.6 per minute, and for each cabin crew member EUR 0.7 per minute are assumed based on surveys [16]. Maintenance, insurance and aircraft depreciation costs are also time-dependent and investigated in some studies [16] [17], which are used here to calculate a cost rate depending on aircraft passenger capacity. To factor in the costs for air traffic control, charges of en-route and terminal navigation services, the principles of EUROCONTROL are applied. Both service charges are calculated similarly and for each local charging zone an individual rate or a European average of EUR 50.61 is used. Airport handling and dispatching fees, representing a 15 % share of DOC, as well as indirect operating costs have no influence on trajectory optimization and are not considered in this study.

In case of a delayed aircraft, the time-dependent cost factors are significantly higher (e.g. compensation for misconnected passengers). In such a case the airline may decide to incur higher speed and fuel costs to reduce delay costs. For each delay minute, additional costs of EUR 2.34 for pilots and EUR 1.02 for cabin crew members are assumed and the maintenance rate for cost calculation is increased by 30 %. On average, soft and hard costs for delayed passengers of EUR 0.2 per delayed minute and passenger are assumed, as long as delay is less than 15 min [16].

Per kilogram of kerosene burned, an aircraft engine emits on average 3160 g carbon dioxide CO_2, 1240 g water vapor H_2O, 14 g nitric oxides NO_x, 0.025 g soot [18]. Each of these emission types and the contrails contribute to global warming and are quantified within a specific EPI. The impact of an EPI on global warming is assessed by the Global Warming Potential (GWP) [18], a measure of the relative effect of the greenhouse gas impact compared to the impact of CO_2. As global climate analyses [18] have shown, 10 % [20] of the total number of flights in 2005 contributed to global warming due to contrail formation as much as 21 % of the total aviation CO_2 emissions in the same year. This means for MEFUL: Contrails are expensive and must be considered carefully.

The CO_2-equivalent emissions can be converted into costs using the Emission Trading System (ETS), which is a powerful tool for translating the environmental impact of emissions into cost functions and thus into objective functions within the trajectory optimization. Using the ETS, companies purchase tradable emission allowances, also called EU Allowance (EUA). One emission allowance corresponds to one ton of emitted CO_2 and the current price per EUA is at approximately EUR 6.50. A continuous reduction in the number of EUAs per company and an expected growing demand for air transport would result in a 10 times higher value of the certificates. For this reason, in MEFUL the price is set to EUR 65 per EUA for the year 2050.

Cost component	Case 1	Case 2	Case 3	Case 4	Case 5
DOC [EUR]	17757	17786	17897	17942	19189
Environ. costs [EUR]	3940	3464	2842	2857	3866
Contrail costs [EUR]	1142	656	0	0	543
Total costs [EUR]	22841	21907	20739	20799	23599

Table 1: Results of the trajectory optimization

Application

The weather scenario for this study has been taken from February 27, 2016, 12 a.m. with a resolution of 1 degree. On this day, a few ISS appeared in the atmosphere at cruising altitude, increasing with height. Two of them were located along the wind-optimal path from Prague (LKPR) to Tunis (DTTA), approximately 240 km and 800 km after take-off (compare *Figure 2* and blue regions therein). There, contrail formation will take place. Furthermore, wind speed and wind direction are shown in *figure 2*. Several lateral routes at different cruising altitudes had been calculated by COALA and

assessed by TOMATO to find out the trajectory with minimum costs.

The number of possible trajectories is large, but may be conflated into five cases, which are discussed in the following and shown in *figure 2* and *figure 3*. Case 1 (orange) corresponds to the base scenario: the aircraft is flying along its fuel-minimum trajectory (250 hPa, FL 340) considering wind speed and direction right through the ISS inducing a contrail. In Cases 2 to 4, the vertical trajectory is adjusted (compare *figure 3*) and in Case 5 the lateral trajectory is varied (as shown in *figure 2*). *Table 1* summarizes the costs of the different trajectories. In Case 2 (green), the first contrail can be avoided by flying below the ISS (FL 290), but in the second ISS the contrail is induced. In Case 3 (purple), both contrails are avoided by flying below both ISSs (FL 290 and FL 300). Although step climbs are expensive, the benefit of contrail avoidance exceeds the additional DOC. In Case 4 (blue), contrails are avoided as in Case 3, but after descending below the second ISS, the aircraft cruises at the lower altitude (FL 300) to avoid an additional vertical movement. However, flying at non-ideal altitude is more expensive than the additional climb phase. In Case 5 (red in *figure 2*), the trajectory is laterally modified at cruising altitude (250 hPa, FL 340) to reduce contrail formation (compare *figure 2*. However, the resulting costs are out of scale).

Conclusion

Under the given atmospheric conditions, lateral adjustment (Case 5) is not an economical alternative, because the costs for additional trip fuel and trip time by far exceed the savings achieved by contrail avoidance (i.e. excessively long detour). Hence, vertical adjustments to the trajectory are recommended because of low increase in DOC. The benefit of additional climb phases to the previous altitudes depends on the remaining distance.

Trajectory optimization considering the environmental impact poses a challenge for the air traffic management, because the input parameters (e.g. weather data) are time-variant and difficult to predict. In the absence of ISS, minimum environmental costs are expected for trajectories with minimum fuel costs. If contrail formation is expected, potentially long detours for lateral adjustments will be often out of the question, whereas non-optimal cruising altitudes and steps are acceptable. ■

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Source: Sophia von Berg

The multi-modal customer

Customer needs and preferences in a world of connected mobility

Multi-modal mobility solutions, connected mobility, customer needs, multi-modal user, market segmentation

Connected mobility is on everyone's agenda. Public and private transport, information technology or sharing services, among others, are seeking to intensify their cooperation activities to provide a diverse and integrated mobility portfolio to their customers. To begin with it would be essential to define these multi-modal customers. What are their needs? Do multi-modal mobility solutions exist that are preferred by these customers and hence should be implemented first?

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The rise of the hybrid consumer who is characterized by situational consumption patterns and the preference for individual bundle offerings instead of single products or services represents a relevant demand-side evolution. Rather than preferring a particular mode of transportation, customers choose the most suitable means of transport for their specific purpose. The system of multi-modal mobility supports this development by providing mobility solutions consisting of a variety of choices that are no longer strictly divided between either private or public transport.

The aim of this study is to understand the multi-modal customers in terms of their needs and preferences. For this purpose, relevant consumer needs have been identified to bring them into relation with various multi-modal mobility solutions. Insights into which multi-modal mobility offer meets which customer's needs allow a detailed description of the multi-modal customers. Furthermore, the mobility market has been segmented into five customer groups. The results to be covered below should be highly useful for practitioners, who aim to develop their marketing strategy for multi-modal mobility solutions.

Methodology

Based on an extensive literature review, we argue that the perceived benefits that consumers look for in a service are mostly expressed through functional and psychologically based values. Hence identifying the structure of customer needs is fundamental for developing successful multi-modal mobility solutions. For this reason, we carried out a focus group study with mobility experts and a secondary analysis of workshop data to identify relevant customer needs. A subsequent survey was conducted during September and November 2015 using Computer Assisted Web Inter-

views (CAWI, n = 1005). We interviewed people between the ages of 18 and 69 who live in German cities with more than 100,000 inhabitants. The stratified sample was selected according to the individuals' age and sex. In addition to their individual needs patterns, participants were asked about their likelihood to use various multi-modal mobility solutions, preferences regarding different means of transport as well as sociodemographic characteristics.

Multi-modal mobility solutions

Multi-modal mobility solutions are integrated combinations of services individually customized for a group of customers. The solutions should provide a better outcome than the sum of the individual components. In the context of mobility, solution offerings will integrate various means of transport and new mobility services into one product. Within the study, five groups of multi-modal mobility solutions were examined:

(1) multi-modal mobility platform
(2) mobility hub
(3) integrated access
(4) integrated fare system
(5) multi-modal premium services

Most of the categories contain multiple solutions differing in configuration details, e.g. a custom-tailored versus a self-learning mobility platform. The multi-modal mobility platform provides information and travel planning features (1). The mobility hub physically integrates different means of transport and further mobility services in one spot (2). An integrated access, either via smart card or via smartphone app, makes multi-modal travel easier (3). An integrated fare system provides one multi-modal fare as a solution (4). Multi-modal premium services, such as mobility insurance, offer additional comfort (5).

The interviewed persons were asked to give their individual probability of use (0 % = wouldn't use the solution, 100 % = would definitely use the solution) for every presented multi-modal mobility solution. Moreover, they had to differentiate between two situations of use: day-to-day mobility and traveling (business & private). The top 3 multi-modal mobility solutions for the whole sample are displayed in *figure 1*.

Within these 3 top-rated services, diverse preferences depending on the situation of use can be pointed out. Getting access to various transport services via smart card is rated the most important solution on a daily basis. Even in the long-distance journey scenario, integrated access via smart card is the second most preferred answer. One can say that usability and simplicity are key to multi-modal mobility.

When it comes to fare models, the suggested "best price" model works out the cheapest fare for all journeys in one month. If a customer used public transit worth a monthly pass, 30 minutes of bike and 4.5 hours of car-sharing services, for example, the invoice will list a monthly public transport ticket, a per-minute-fee for bike sharing and a 240-minute car sharing package at a fixed price plus a per-minute-fee for the remaining 30 minutes. Both day-to-day and long-distance travelers seem to value the flexibility of the "best price" fare model, as they rely on its transparency and the benefit of potential savings.

The custom-tailored mobility-platform – in the form of a smartphone app or a website – offers an individually customizable user interface. It is most popular with planning business or private long-distance trips. In contrast, a self-learning platform that adapts its interface, offerings and provided information through analyzing the customer's mobility behavior is – no matter what situation of use – at the ranking's bottom. Data privacy issues could probably be one of the factors that would explain the results. Assuming that day-to-day mobility is mostly characterized by routines such as commuting, multi-modal travel information and planning platforms are not equally in demand here.

Figure 2 illustrates the respondents' preferences regarding add-on services for multi-modal mobility platforms.

Real-time data and single-sign-on (one registration process per customer) are obviously the most preferred add-on services for multi-modal mobility platforms in any situation of use. A live cost overview seems useful on a daily basis, whereas long-distance travelers are looking for integrated booking options. The results reveal that two out of the four highest ranked add-on services rely on dynamically synchronized data transfer,

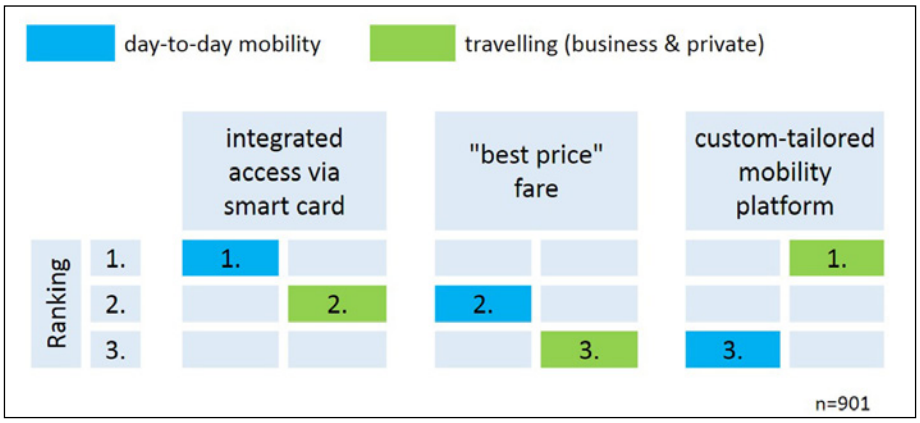

Figure 1: Top 3 multi-modal mobility solutions

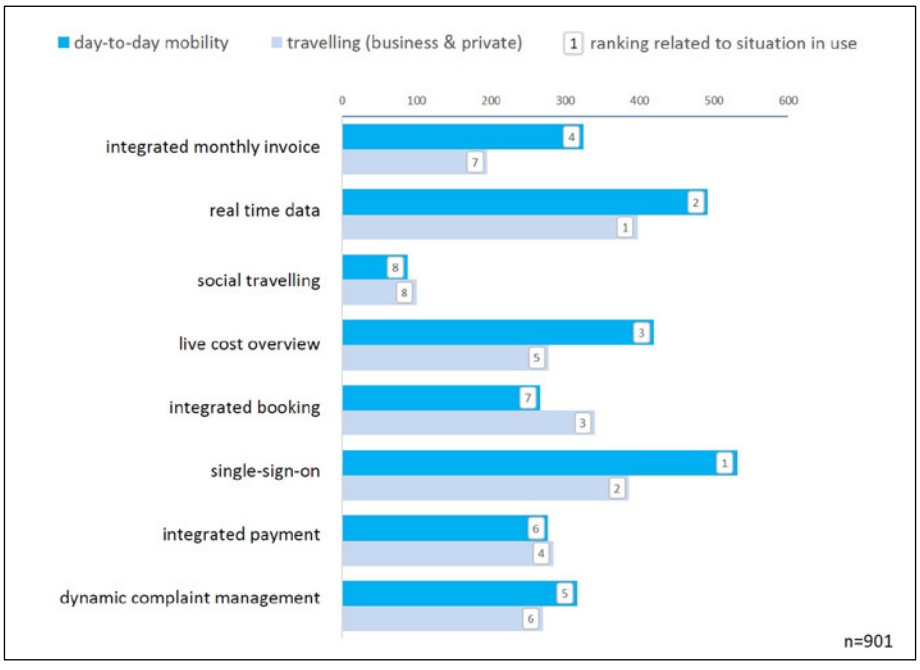

Figure 2: Add-on services for multi-modal mobility platform

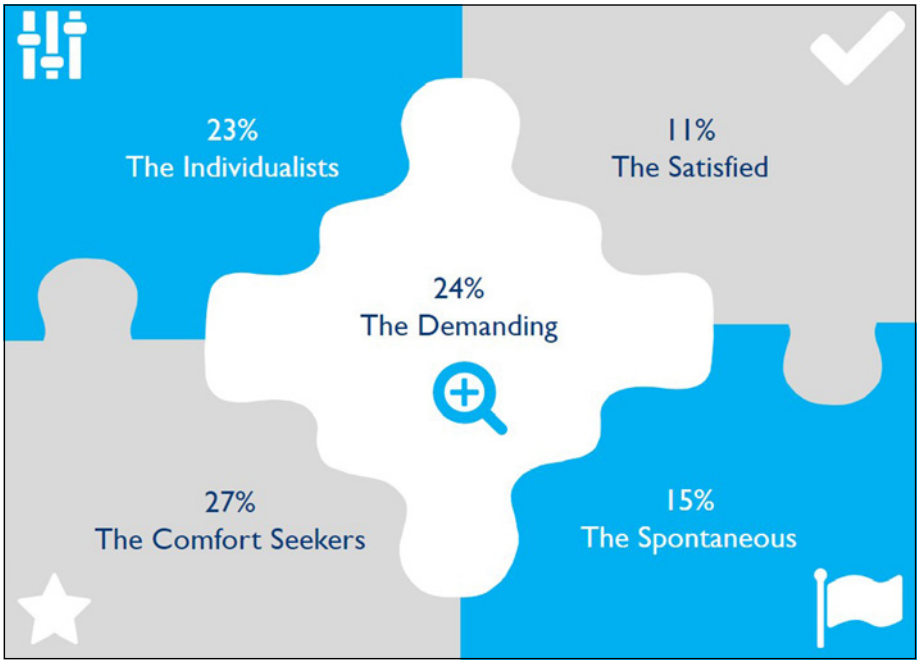

Figure 3: Five customer segments for the connected mobility market (n = 901)

hence the customer stays informed in every traveling situation. Social traveling, a travel community and chat service only just introduced in Germany by Axel Springer SE (Lokin App), ranks lowest.

The influence of customer needs

Within the scope of this study we wanted to understand if particular needs do have an influence on the customers' willingness to use or dismiss a multi-modal mobility solution. Since the transferability to other empirical studies was a requirement, the following generic needs that are not embedded in a special mobility context were examined:

(1) *Appreciation* describes the desire to be acknowledged for either cognitive abilities or rather materialistic status symbols.
(2) *Comfort* reflects the demand for convenience and classy surroundings.
(3) *Data Privacy* is the need for personal data protection and confidentiality.
(4) *Flexibility & Simplicity* describes both the demand for options that enable spontaneity and the need for an easy handling of services and products.
(5) *Individuality* expresses the request for customizable products and services, whether actively individualized by the users themselves, or custom-tailored by the provider.
(6) *Safety & Support* describes the need for safety in dealing with different situation as well as the openness towards external support.

The need levels were measured through at least three question items on a 6-point Likert scale. Within various regression analyses, the relationships between particular needs and the willingness to use multi-modal mobility solutions could be investigated. On average, 8.3 % of the variance regarding the likelihood to use multi-modal mobility solutions could be explained by socio-demographics (age, sex, occupation). On top of that, customer needs were able to explain another 20.2 % of variance. It was statistically proven that differences in customer needs have a relevant influence on the willingness to use multi-modal mobility services.

The *Need for Economy*, *Scrutiny* and *Efficiency (time)* were also measured as factors, but excluded throughout the multivariate analysis. Those needs could not be proven to be significant in terms of a statistical connection to the likelihood of multi-modal service use.

The interdependency investigation of customer needs and the willingness to use multi-modal mobility solutions draws a clear picture. A varying degree of the needs *Individuality*, *Appreciation* and *Comfort* has the greatest influence on whether a person will use or dismiss multi-modal mobility services – the higher one of these needs is rated, the higher the likelihood to use a multi-modal service. The demand for *Safety & Support* and *Flexibility & Simplicity* also raises the willingness to use multi-modal mobility solutions, but plays a minor part. In contrast, the higher the need for *Data Privacy*, the higher the likelihood to refuse multi-modal services. In summary, it can be stated that customer needs have a significant influence on the willingness to use multi-modal mobility solutions. Moreover, correlation analysis revealed that rather demanding customers are more likely to use these offerings.

Accordingly, customer needs, especially *Individuality*, *Appreciation* and *Comfort*, should be taken into account within every service design process. In this manner, potential multi-modal customers with a higher likelihood to use new mobility solutions may be reached. A reliable data privacy concept should be implemented to break down further barriers.

Since the lack of significance of both the *Need for Economy* and the *Need for Efficiency (time)* was rather unexpected, these scales should be re-examined in the field as soon as a multi-modal mobility solution is in use.

Customer segments in a new mobility market

Besides a constant rollout of new mobility offerings, such as car- and bike-sharing schemes, as well as the creation of other sharing services, new business areas with a high potential for differentiation evolve and bring a rise of new inter-sectoral cooperation opportunities. The subsequent convergence of markets and business models forms a new mobility market instead of segmented sectors for individual and public means of transport. It is about time that new market segmentation approaches focusing on multi-modal customers be developed. Using the method of cluster analysis, five customer segments, distinguished by their individual need patterns, could be derived (see *figure 3*).

The Individualists are mostly attracted by products and services that are actively customizable. Security-conscious data handling is still a key concern. They are not worried about other safety issues. An unfamiliar environment, for example, does not scare them. Furthermore, Individualists are seeking for appreciation for their cognitive abilities. With regard to their mobility behavior, Individualists are mostly multi-modal with advance towards public transit and cycling.

The Satisfied are not the demanding type of persons. As long as a service allows some adaptability and flexibility, they are pleased. On the other hand, they strictly refuse every form of self-display, whether it be appreciation for cognitive abilities or materialistic status symbols. *The Satisfied* are highly attached to their personal car, a great percentage can be assigned to the traditional mono-modal motorist.

Unlike the aforementioned customer segment, *The Demanding* are rather hard to please. They are seeking safety and support;

assistance, for example, is well received especially in an unfamiliar environment. They set great value upon data privacy and also call for all forms of appreciation. Furthermore, *The Demanding* enjoy some degree of simplicity, easy handling and comfort. Multimodality characterizes this segment's travel behavior. They are open-minded towards new mobility services, such as car and bike sharing or app-based offerings.

The Comfort Seekers put great store on style and convenience. In return, data privacy and flexibility are irrelevant to them as long as a high level of comfort is guaranteed. *Comfort Seekers* depend on the car, but would be open to using other modes depending on the situation.

The Spontaneous demand overall flexibility and pure simplicity at the same time. Spontaneous actions have to be possible in every situation and shall be accompanied by easy handling of products and services. *The Spontaneous* want to be acknowledged for their cognitive abilities rather than for materialistic status symbols. They put no value on a high level of individuality, safety issues or extra comfort. When it comes to their mobility patterns, they mostly rely on the car.

Using the analysis of variance, two main cluster subsets that vary in their preferences could be identified. Whereas *The Individualists*, *The Demanding* and *The Comfort Seekers* are more likely to use multi-modal mobility solutions in general, *The Satisfied* as well as *The Spontaneous* are more skeptical towards these services. As mentioned earlier, an above-average need for individuality, appreciation or comfort strongly increases the willingness to use multi-modal mobility solutions. Since *The Individualists*, *The Demanding* and *The Comfort Seekers* are quite open-minded as regards different means of transport and new sharing services, and their need patterns are characterized by at least one of the values mentioned above, their openness towards multi-modal mobility solutions is not far to seek. Once more, it becomes obvious that demanding customers are more willing to use multi-modal solutions. On the other hand, it has to be assumed that multi-modal mobility services do not meet the need for flexibility and simplicity, since these values are of particular importance to *The Spontaneous* as well as *The Satisfied*. Accordingly, providers should simplify the use of multi-modal mobility and realign their communication strategies to break down further acceptance barriers.

Conclusion

The study's results bring substantial insights into the needs and preferences of the multi-modal customer. When designing new multi-modal mobility solutions, practitioners should focus on the satisfaction of customer needs, particularly on attributes that meet the need for *Individuality*, *Appreciation* and *Comfort*. The usability of these services has to be increased too, since the respondents did not link multi-modal solutions to a high level of *Flexibility & Simplicity*. Providers who want to implement multi-modal mobility elements in their offering should initially focus on integrated information and access as well as a multi-modal fare system. The most important add-on services, such as multi-modal real-time information and single-sign-on, should also have priority in the development process. In conclusion, the presented market segmentation along with the other results of this study is of great importance for both designing multi-modal mobility solutions and implementing a successful marketing strategy. ■

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Cooperative advanced driver assistance systems

Technological measures for data privacy compliance

Informational self-determination, digital signature, Car-to-X communication, Big Data analysis

Cooperative advanced driver assistance systems (ADAS) will contribute to road traffic safety: Critical situations will be detected, the driver alerted and control of the vehicle interfered with automatically. However, the introduction of such driver assistance systems presupposes that data privacy issues have already been solved in advance. A necessary condition for the driver to accept and trust new driver assistance systems is that his/her personal and personally identifiable data will be treated with a high level of integrity.

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This article presents an approach to maintaining a high level of integrity in dealing with this data.

Weighting rivaling legal interests

Technological implementation of cooperative advanced driver assistance systems (ADAS) reveals two rivaling legal interests:

1. The protective effect of active safety systems and, accordingly, the individual right to life and physical integrity (see EU Charter of Fundamental Rights)
2. The right to informational self-determination (see EU Charter of Fundamental Rights)

Protective effect of ADAS

The United Nations' Decade of Action for Road Safety campaign goal is to reduce traffic accidents worldwide by 50 % by 2020. Reaching or even exceeding this target (i.e. "Vision Zero"), requires a comprehensive integrated traffic safety work plan (Ahrens, et al., 2010). Advanced driver assistance systems play a major role in achieving this objective. Ahrens distinguishes three different levels of ADAS:

1. Systems that recognize a vehicle's movement and compare it with the driver's intentions (anti-lock braking systems)
2. Systems that additionally use environment-related data provided by the vehicle's sensors (lane keeping assistance systems, LKAS)
3. Systems whose sensors also provide the vehicle with otherwise inaccessible information (front collision warning systems, FCWS) (Franke, et al., 2013)

Vehicle-to-vehicle and vehicle-to-infrastructure (V2I) communication will allow all motorists to "cooperate" (Köster, 2014). This will improve traffic flow and increase traffic safety.

Right to informational self-determination

Dedicated Short Range Communication (DSRC) according to ETSI ITS G5 standards sends information on traffic light signal times or existent traffic regulations (e.g. speed limits). Besides merely transferring data for the respective use cases, it is essential that deliberate falsification or manipulation of the signals sent be prevented. As a basic principle all vehicles and traffic light control units need to be protected against manipulative information and any kind of attacks. *Figure 1* illustrates intelligent traffic system attack vectors. Said protection should comply with process and technical specification defined per international standards for programmable traffic control and surveillance application system development (DIN, 2008) and functional road vehicle safety (ISO, 2011).

Technical solutions are based on systems in which outgoing communication is equipped with a digital signature, the validity of which is verified on the recipient side. This requires taking technical and organizational measures for certification and, in case of doubt, revocation of the same. Current communication protocol specifies cyclic codes for cooperative advanced driver assistance systems use cases (Köster, 2014). The cooperative ADAS transmits said codes, which categorically include personally identifiable information (i. e. vehicle ID) at intervals of a few seconds as well as use-case-relevant parameters, such as speed, direction and location of the motorist:

- Cooperative Awareness Messages (CAMs) convey information on the presence, whereabouts, speed, sensor data and current status of communicating, neighboring ITS stations. These are used for instance to warn drivers of potential collisions at intersections.
- Decentralized Environmental Notification Messages (DENMs) send situation-specific local hazard warnings (Franke, et al., 2013). A typical use case is a road hazard warning, which consists of multiple applications.

The data sent from ITS station to ITS station is not only applicable to the initially intended purpose of driver assistance. This data may also be used for tasks of public authorities, e.g. authorized criminal investigation or prosecution of speed limit violations or similar (Rannenberg, 2015). This allows driver profiles or "digital traffic tickets" to be issued. On the one hand, digital signatures enable authentication. On the other hand, they represent personal and personally identifiable data or much less distinguishing marks that can potentially reveal a communication partner's identity. Consequently, from the point of view of privacy legislation, communication of car-identifying signatures of the transmitted messages should be viewed critically. After all, such administrative interference with the right to informational self-determination requires a purpose or basis for author-

ity regulated by law, i.e. an enabling provision (Kost, et al., 2013).

Privacy law framework

Advanced driver assistance systems support and inform the drivers and increasingly relieve them of certain tasks. According to Bendel (2014), this raises information ethics questions. Personal rights and interests should be understood, respected and observed when information technology is applied. Information ethics groups emphasize the importance of protecting and preserving informational autonomy under ADAS. Accordingly, ethical standards have been set out in writing in relevant legal standards and legislation (e.g. Directive 95/46/EC). Each individual has the right to command and determine their own personally identifiable data. Since implementing and using intelligent traffic system (ITS) applications and services implies processing personally identifiable data (EU, 2010), protecting data privacy interests is imperative.

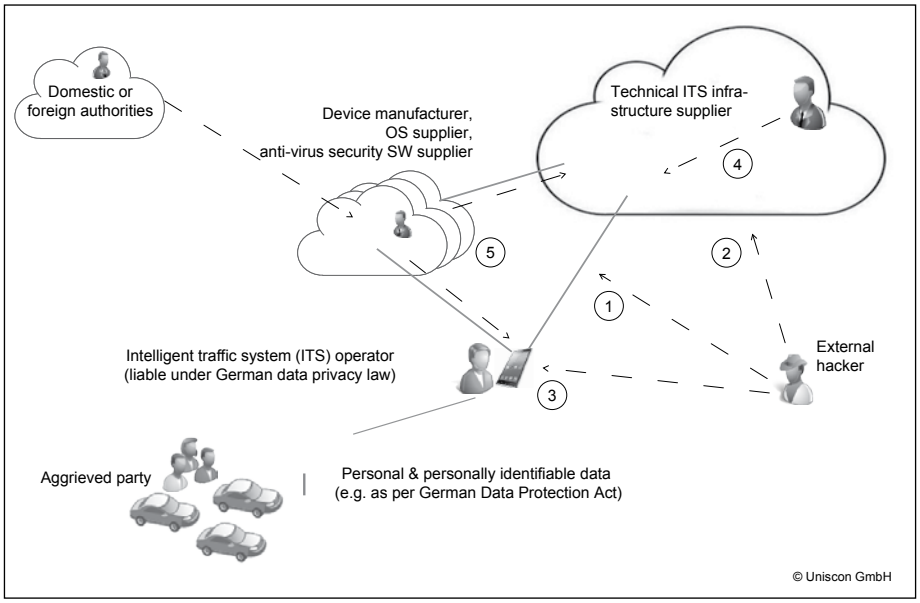

Figure 1: Intelligent traffic system (ITS) attack vectors

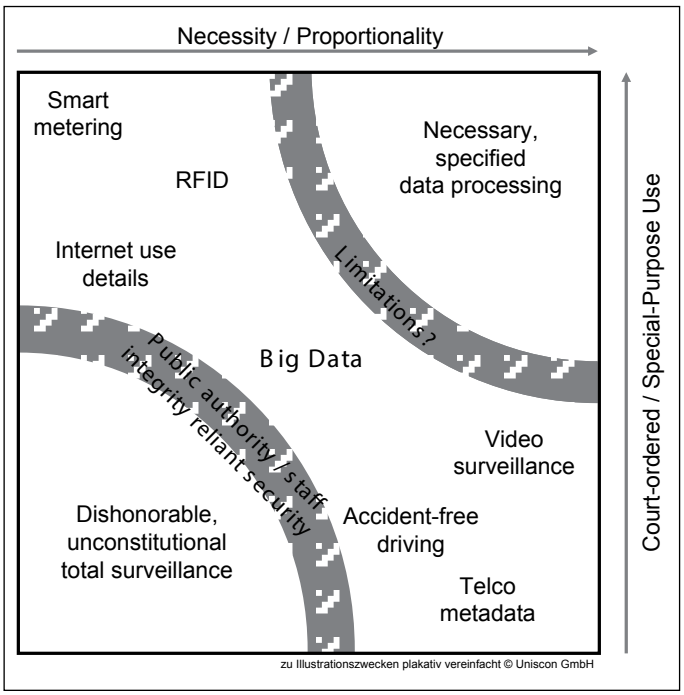

Figure 2: The special-purpose and proportionality challenge

Principle of proportionality

The latter also means that any action of the authorities must remain commensurable and observe the principle of proportionality. This rule of law ("prohibition of disproportionate measures") is statutory and for example laid down in the German Constitution. "Proportionate" (i.e. commensurate) implies that any action taken by the authorities must be *appropriate*, *necessary* and *reasonable* as to the purpose to be served (Keil, 2014). A measure is defined as *appropriate* if it serves to achieve the set objective. It is considered "*necessary*" if deemed the "mildest" of all adequate measures and "*reasonable*" if and when proportionate with the objective pursued. Consequently, EU ITS Directives (EU, 2010) stipulate that personal and personally identifiable data may merely be processed if and when necessary for ITS application and service operation.

Principle of special-purpose use

The principle of special-purpose use pursuant to the relevant EU Directive (EU, 2010) is also valid for ITS applications. The mentioned principle indicates that the right to informational self-determination may merely be restricted to the "inevitable". The special-purpose principle stipulates that the acquisition, use and storage of personally identifiable data may only be ascertained for specifically defined, explicit legitimate purposes. Moreover, further processing (i.e. use, modification, linkage and storage) of personal data is only admissible to the extent that it remains reconcilable with the respective special purpose (Rannenberg, 2015). The period and amount of data that may be processed is strictly limited to the amount needed to achieve the given objective (Keil, 2014) (Douma et al., 2012).

Resulting challenges for privacy-compliant Big Data analysis

The aforementioned elementary principles of proportionality and special-purpose use span the fields of activity shown in *figure 2*. As shown in the bottom left corner, in the worst-case neither objective is achieved. At best (top right), both objectives are fulfilled. However, the party amenable to law (the official investigative authority) must comply with the data subject's rights. The person concerned must be informed, has the right to delete or block data, and the right to objection (Douma et al., 2012). Compliance with regulations concerning the data subject's consent to processing of personal data (EU, 2010) must also be observed, provided that there is no legitimate purpose regulated by law. In cases where a large quantity of data is consolidated, a specific explanation as to its purpose and processing or use is required. If the data subject does not effectively consent to the processing and use of his/her data, so-called "reasonable initial suspicion" postulates the existence of at least "sufficient actual" evidence, to be able to presume a criminal offence or misdemeanor.

According to the European Court of Justice (ECJ), storage of Big Data is irreconcilable with the EU Charter of Fundamental Rights. Also the German Federal Constitutional Court's First Senate has declared data retention to be altogether "unconstitutional and null and void by law", ordering that data stored to date be deleted with immediate effect. In its court opinion the court frames material, organizational and procedural specifications regarding data storage, transfer and usage: It must be assured that security standards reflect the technical discussion's development, continuously incorporate the latest scientific findings and insights, and are not subject to the free weighing of economic interests (Federal Constitutional Court decision dated 3/2/2010, 1 BvR 256/08).

In the following, we introduce a technology that ensures the protection of the authorities' interests pertaining to the aforementioned legal principles.

Sealed Freeze and Sealed Analytics solutions

Both technical solutions, Sealed Freeze (data-privacy-compliant data retention) and Sealed Analytics (compliant Big Data) are based on the fact that the potential of Big Data may only be used if any risk of uncontrolled data distribution and data abuse is eliminated. A combination of intelligent technologies, updated applicable law and technical regulations can ensure this. The data privacy technology mentioned herein allows performing Big Data analyses while maintaining a high level of integrity when dealing with personally identifiable data (Rieken, et al., 2015).

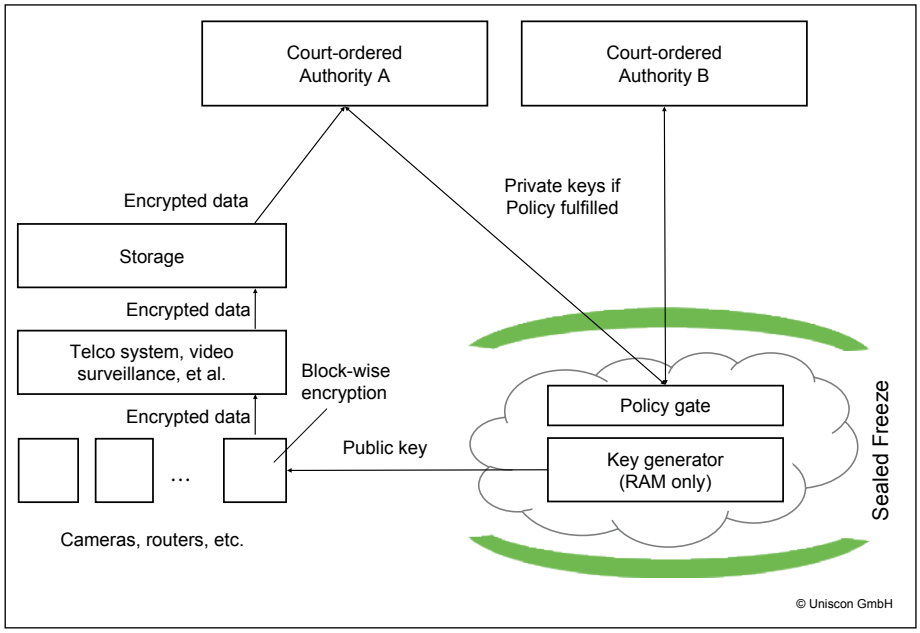

Figure 3: Sealed Freeze application components

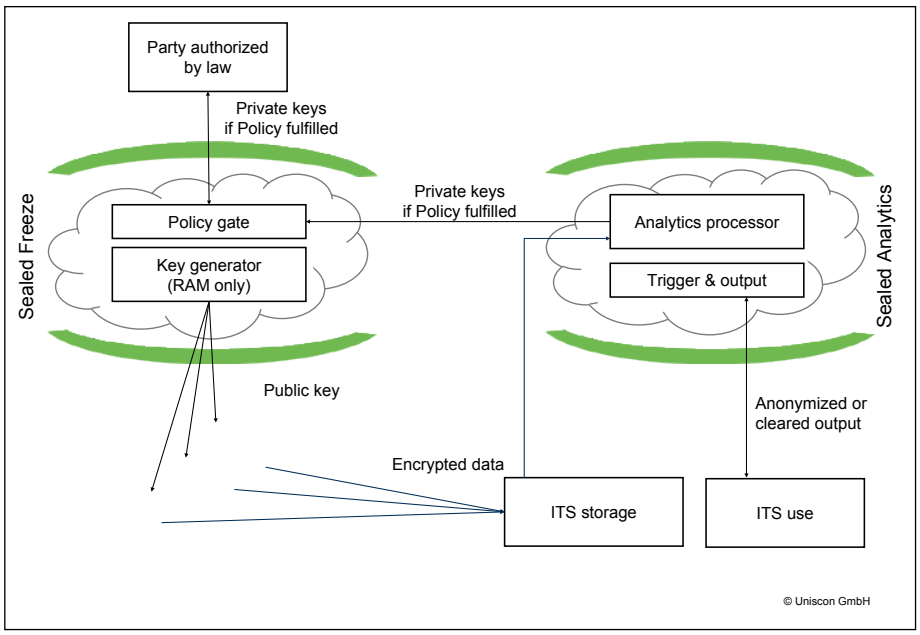

Figure 4: Privacy compliance for Big Data via Sealed Analytics

Storage in a sealed environment

The sealing technology is based on the fact that only specifically defined and technically verifiable parties can access data. Access control specifies who may work with personally identifiable data to what extent. Since provider staff cannot access Sealed Cloud data at any time (Jäger et al., 2013), a "key generator" is necessary to create a vast amount of asymmetrical pairs of keys. Public keys can then be exported to where the data is collected, in order to encrypt the data block-wise. Private keys, which are necessary for decryption, are stored per multi-redundant, yet (merely volatile) random-access memory (RAM) within the Sealed Cloud. This type of storage ensures, via Sealed Cloud security, that no one can access unencrypted storage data, neither per authorized nor per unauthorized access. Planned access, e.g. during maintenance, or unplanned access, such as cyber attacks, triggers an alarm and automatic data clean-up.

Sealed Freeze and Sealed Analytics access per policy gate

The core characteristic of the technology is that access to data stored in this manner is granted technically, i.e. by a set of fixed rules (policy) specified in advance (Kost, et al., 2013). Said policies are subject to data privacy specification. Consequently, differing individual policies may be created for Big Data. These are subject to a three-layer formula:

- The first level of protection fulfils the minimum legal requirements of data privacy law.
- The second level includes supplementary data privacy specifications covenanted with the user.
- The third level of protection is a particularly commendable example of implementation of the principles of data privacy, e.g. in terms of data austerity or privacy by design (Douma, et al., 2012).

A judicial decision, i. e. court order, is the condition precedent for a person to be authorized access to personal or personally identifiable data. Client certificates can verify an authorized party's identity with certainty, since they are allocated to specific devices. If an authorized party must access personal data or metadata for investigative

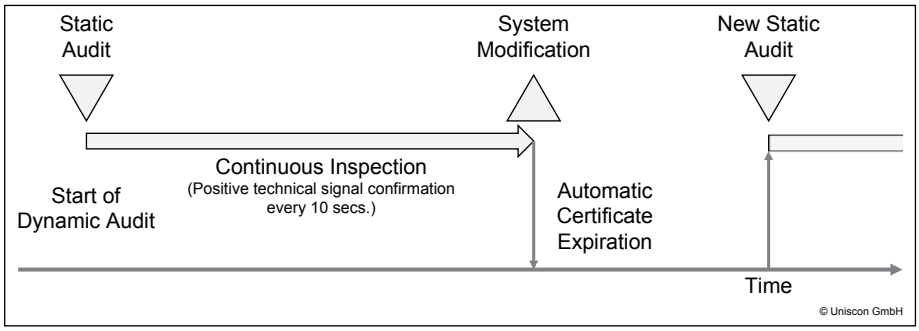

Figure 5: Dynamic audit

purposes, then this is merely feasible via policy gate. The policy gate implements a logic that is strictly modifiable for versioning only. Reverse modification of the logic is impossible. *Figure 3* illustrates the aforementioned Sealed Freeze components.

Sealed Analytics

Sealed Analytics technology is based on the above principle and enables specific, court-ordered analysis of data, provided that the corresponding semantics are allocated prior to storage and a set of metadata has been accumulated. Accordingly, specific rights allocation allows authorized parties access to specific data. Said authorized parties are also only granted access to personally identifiable data that is needed to perform the respective task. Up-front policy specification allows access criteria to be defined individually. For example, access might be granted for specific data types only, or limited periods of time, limited data volumes, and specific types of traffic or usage rights. Any access that is not intended for special-purpose or court-ordered use is denied. Modification of a policy is possible yet ineffective in case of existing data. The modified policy only kicks in after the moment of modification, i.e. with future data. Hence, Sealed Analytics ensures better data privacy. *Figure 4* illustrates how Sealed Analytics ensures privacy compliance for Big Data.

Auditing as accompanying organizational measure

Impartial, independent auditing ensures methodical, documented examination of a system. It determines whether quality-reliant activity and concomitant analysis is conducted according to specification and meets the set objectives (audit criteria). A successful audit fulfils specific criteria and conforms to defined requirements. It also implicates two separate procedures that complement each other: A static audit evaluates something according to "handbook". It analyzes whether process documentation meets the set standards specified therein. In contrast, dynamic audits (illustrated in *figure 5*) go much further. The latter consist in continuous system testing.

Conclusion and outlook

Cooperative advanced driver assistance systems based on Car-to-X communication will improve road traffic security considerably. For large-scale application, consumers have to be convinced that these systems improve traffic safety and convenience alike. At the same time, information ethics and legal requirements must also be considered. Hence it is imperative that all data is handled with integrity. Sealed Analytics ensures overall compliance and privacy protection of Big Data from road traffic. It comprehensively safeguards personally identifiable ITS data against abuse, unauthorized access, manipulation and theft. After all, the described technology ensures data privacy observant, compliant analysis, i.e. the sine qua non of political and public acceptance. ■

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Projects in a nutshell

Overview of selected mobility research projects

Robotic falcon to scare away birds at airports

Nico Nijenhuis, Master's student at the University of Twente and CEO of Clear Flight Solutions, with "Robird" Photo: Clear Flight Solutions

At Weeze Airport in Germany, just across the Dutch border near Nijmegen, the life-like robotic falcon "Robird" made its first flights at an airport location. Developed by Clear Flight Solutions, a spin-off company of the University of Twente, the Robird is designed to scare away birds at airports and waste-processing plants.

The cost of bird control at airports worldwide is estimated in the billions, and does not consist only of material damage, as birds can also be the cause of fatal accidents. Across the globe, birds also cause damage running into billions in the agrarian sector, the waste disposal sector, at harbours, and in the oil and gas industry. A common problem is that, since birds are clever, they quickly get used to existing bird control solutions and simply fly around them. The high-tech Robird, however, convincingly mimics the flight of a real peregrine falcon. The flying behaviour of the Robird is so true to life that birds immediately believe that their natural enemy is present in the area. Because this approach exploits the birds' instinctive fear of birds of prey, habituation is not an issue.

The Robird is the flagship product of Clear Flight Solutions – a robotics and drone spin-off company of the University of Twente. The company was recently the beneficiary of an investment of EUR 1.6 million from Cottonwood Euro Technology Fund. This investment has enabled Clear Flight Solutions to become a global leader in the field of bird management. The link with research and teaching at the University of Twente is still strong – in February, three new graduates started work at Clear Flight Solutions. There has also been a lot of interest from Saxion University of Applied Sciences. The work goes further than just electrical and mechanical engineering. Clear Flight Solutions are working on multidisciplinary solutions to social issues. *red*

More information: https://www.utwente.nl

Wireless communication between vehicles in a 5G world

Researchers from the Universitat Politècnica de València (Polytechnic University of Valencia, UPV) have devised and configured a new 5G radio access system for intervehicular communication. The system is intended to improve road safety in a future scenario where 5G technologies are the norm. It was presented at the Commission's stand at the Mobile World Congress held in Barcelona in February 2016. A continuation of the METIS project, METIS-II is an international project funded by the European Commission under Horizon2020 to research the efficient integration and use of various 5G technologies and components. Among its end goals is to optimise the performance and interconnection of in-vehicle mobile communications systems and, by doing so, contribute to improved road safety and lower traffic accident rates – though this is just one of many possible 5G applications.

The main novelty of the new system is that it allows the continual adjustment of waveforms in such a way that vehicles can communicate with each other, thereby overcoming the hurdle of not having a set station for communication. In terms of hardware, the system presented in Barcelona includes three programmable cards, each of which has a high-performance FPGA (field-programmable gate array) to integrate different waveforms, which are what carry data through the air, and four antennas. These cards will allow direct communication between vehicles, as well as the integration of intervehicular communications into conventional mobile communication systems. *red*

http://www.upv.es

To show how it will work, the iTEAM researchers have developed a virtual environment that replicates the streets of Madrid.

Their demo video can be found here:
https://www.dropbox.com/s/g2bwjs9hckwkroj/WP_20160223_17_39_47_Pro.mp4?dl=0

Real environmental data in real time for simulations

Engineering departments at large automotive companies today use simulation when conducting virtual tests during the development phase of their new vehicle designs. This involves computing the physical properties of the cars in advance, which significantly shortens the testing loops with real test vehicles that often span several years. This approach is already applied, for example, in testing passive safety, acoustics, durability and reliability, as well as energy efficiency, fuel consumption and carbon emissions. At present, vehicle behavior can be simulated very well using software tools.

However, it is difficult to simulate environmental influences that have a significant effect on the automobile while driving, such as street conditions, weather and driving maneuvers. Experts often work with assumptions rather than with actual measured data because generating the real-life data and making it relevant for simulations is complex and expensive.

Big Data expertise brings large amounts of data under control

Researchers at Fraunhofer Institute for Industrial Mathematics (ITWM) now are offering a quick and inexpensive system that collects real data at normal driving speeds and processes this data in real time as fine-grained and coarse-grained data for 3D driving simulations. The system consists of a test vehicle, a geo-referenced database and a vehicle simulator. Using two 360-degree laser scanners, the Road & Environmental Data Acquisition Rover (REDAR) captures enormous amounts of environmental data at normal driving speed – so called point cloud data. This means: Environmental data exist for each 3D coordinate. The ITWM researchers have managed to prepare the terabyte-sized dataset so that it can be used in real time in 3D interactive driving simulations. The volume of data is so large that the data cannot be easily fed into the memory of a computer system. Therefore the researchers have developed an out-of-core method to process only the data necessary for the running time in the simulator.

REDAR captures data from the building fronts to the left and right and from the street in front and behind of the vehicle up to a distance of 200 meters. It also scans the road's surface with a resolution of less than half a centimeter. An inertial platform eliminates potential movement of the vehicle from the raw data of the laser scanner so that it can be objectively processed by the software. The test vehicle has been in use since 2015 and has already been collecting data for various customer projects.

Merging fine- and coarse-grained data

ITWM's own driving simulator RODOS (Robot-based Driving and Operation Simulator) converts the metrics collected by REDAR. The simulator consists of a cabin system in which a steering wheel, gas and brake pedal can be operated. The driver cabin is connected to a 6-axle robot system that realistically simulates acceleration and braking maneuvers or driving around tight curves. That is why the test driver moves through a virtual world that feels very realistic after just a few minutes. The simulations are supported by data from the database system known as Virtual Measurement Campaign (VMC). The database re-creates the world's road network with its topography, regulations, weather and additional geo-referenced data. With the data collected from the data acquisition vehicle they merge real fine-grained data with the coarse-grained data from the VMC. *red*

The Fraunhofer ITWM system includes realistic environmental influences in driving simulations. Photo: Fraunhofer ITWM

More about Fraunhofer Institute for Industrial Mathematics ITWM:
http://www.itwm.fraunhofer.de/en/fraunhofer-itwm.html

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Self-driving mining truck

A self-driving truck under development by Scania and Swedish research universities has tested successfully at speeds of up to 90 kilometers per hour. According to research carried out at KTH Royal Institute of Technology, the successful tests are aimed at implementing self-driving Scania trucks in mining operations within a year or two. The truck drove itself with a maximum deviation of 20 centimeters from the road's center line and travelled softly and stably even at its maximum speed of 90 km/h. A demonstration test in a real mine is scheduled for the late autumn.

KTH, Scania, Linköping University, Saab and Autoliv are collaborating in a government-funded project called iQMatic, which aims at developing a fully self-driving truck for difficult environments such as mines. The concept has been developed to the point where the truck can safely handle obstacles on the road and carry out tasks such as picking up and unloading gravel. Several researchers from KTH are participating in the project. Using Model Predictive Control (MPC), the truck can drive autonomously on narrow and winding roads.

The model can predict the vehicle's movements in every given situation, on the basis of information about what direction it's being steered in, how much throttle is given and alternatively how much braking force is applied. MPC makes it possible to minimize deviations from the intended path, and maximize passenger comfort, by reducing side-to-side jerks in the steering, as well as by targeted acceleration and braking maneuvers. It can also optimize the vehicle's fuel consumption. With greater mass and built-in inertia than passenger cars, trucks present a greater challenge for autonomous driving. The Scania truck used has two steering axles. The truck's calculation model thus has to be more complex and resource-intensive. Self-driving trucks need new information every 50 milliseconds to make the right decisions about the steering, accelerator or brakes.

Further information:
KTH Research: https://www.kth.se/en

Flake-like nanoparticles offer reliable rust protection

Large quantities of steel are used in architecture, bridge construction and ship building.

Various techniques are used to prevent corrosive substances from penetrating into the material. One common method is to create an anti-corrosion coating by applying layers of zinc phosphate. Now, research scientists at INM (Leibniz Institute for New Materials) developed a special type of zinc-phosphate nanoparticles. In contrast to conventional, spheroidal zinc-phosphate nanoparticles, the new nanoparticles are flake-like. They are ten times as long as they are thick. As a result of this anisotropy, the penetration of gas molecules into the metal is slowed down.

In first test coatings, the scientists were able to demonstrate that the flake-type nanoparticles are deposited in layers on top of each other, thus creating a wall-like structure. This means that the penetration of gas molecules through the protective coating takes longer because they have to find their way through the ´cracks in the wall´. As a result, the corrosion process was much slower than with usual coatings based on spheroidal nanoparticles.

In a further series of tests, the scientists were able to validate the effectiveness of the new nanoparticles. To do so, they immersed steel plates in electrolyte solutions with either spheroidal zinc-phosphate nanoparticles or with flake-type zinc-phosphate nanoparticles After just half a day, the steel plates in the electrolyte solutions with spheroidal nanoparticles were showing signs of corrosion whereas the steel plates in the electrolyte solutions with flake-type nanoparticles were still in perfect condition and shining, even after three days. The researchers created their particles using standard, commercially available zinc salts, phosphoric acid and an organic acid as a complexing agent. The more complexing agent they added, the more anisotropic the nanoparticles became.

Leibniz Institute for New Materials INM is an institute of the Leibniz Association and has about 220 employees.

More information: http://www.leibniz-inm.de/en/

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Liquid electricity: The world's first formic-acid-powered city bus

VDL Bus & Coach and Team FAST, a group of students from Eindhoven University of Technology, collaborate on the development of the world's first city bus that runs on formic acid. While VDL Enabling Transport Solutions (VDL ETS) is constantly looking for new technologies that make it easier to extend the range of zero-emission transportation, the conversion of formic acid to hydrogen is one of these promising new technologies. VDL ETS focuses on the strategic importance of E-Mobility and carries out all pre-development projects in the area of innovative transport solutions within VDL Groep.

Formic acid, or methanoic acid, is a chemical substance that also occurs in nature (ants). As a chemical product it is used for various applications. Researchers at Eindhoven University of Technology have discovered a way to quickly and efficiently transform hydrogen into liquid formic acid and back again into hydrogen.

Formic acid as liquid energy carrier can be stored and transported much more easily. Existing filling stations can be used for the energy supply, because a bus that runs on formic acid does not need to be recharged but rather fills up with formic acid, like filling a tank with diesel. This means no emission of harmful gases and a much greater range than what is currently common for vehicles with alternative powertrains.

The bus that will be converted to the world's first formic-acid-powered bus is a VDL Citea Electric with a length of 12 metres. The modular construction of the Citea range makes it possible to choose from various electric drive systems, battery packs and charging systems. This allows the selection of the ideal and optimal combination for each deployment area. The modular design also facilitates the necessary adaptations for driving on formic acid, without affecting accessibility, interior layout or comfort.

Team FAST is a group of about 25 students from Eindhoven University of Technology. This group is engaged in the development of technology that can use formic acid as a renewable, liquid, innovative energy carrier. The team was formed in September 2015, and just four months later, on 14 January 2016, they presented a model car powered by this new discovery. Since then, Team FAST has set to work to further develop its technology to make it suitable for large vehicles too. Because Team FAST strives for a sustainable world and truly wants to make a contribution, the decision was taken to enter into a partnership with VDL. In this way Team FAST intends to demonstrate that formic acid is an attractive solution for sustainable mobility. *red*

Carpenter ant (Camponotus ligniperda)
Photo: Richard Bartz/Wikipedia

Further information
VDL Bus & Coach: http://www.vdlbuscoach.com
Team FAST: http://www.teamfast.nl/

The future of urban living

Preview: 31 May–05 June 2016 – Metropolitan Solutions congress and exhibition, Berlin (DE)

Photo: Berlin Fair

How can we make our cities more livable? How can cities contribute to the achievement of global climate targets? And what is the way forward for improved urban mobility and energy supply? These are the kind of questions to be discussed at Metropolitan Solutions 2016 – in its second season at Berlin's CityCube convention complex. Metropolitan Solutions comprises more than 30 high-power conferences and workshops on intelligent, sustainable urban development plus an extensive exhibition program featuring the latest urban development technologies and solutions from leading international companies and organizations. The combined congress and exhibition runs from May 31 to June 2. It will bring together decision-makers and leaders from around the globe for high-level dialogue on current and emerging issues and challenges in innovative urban development. Among the big highlights is the German Habitat Forum 2016 – Germany's principal contribution to the UN-Habitat III program.

The big urban centers of the world are the laboratories where transformative technological solutions for tomorrow's cities are developed. Berlin is already well known as a place where stakeholders from business, science and government actively work together to develop new ideas and products for tomorrow's cities.

The individual conferences that make up the congress program are organized by various independent expert partners. The German Habitat Forum on June 1 and 2 is an example of this. Organized by the German Federal Ministry for Economic Development and Cooperation and the Berlin state government in partnership with several federal-level government agencies, it is a key platform for discussion on sustainable solutions for tomorrow's cities. The ideas and concepts that emerge from the German Habitat Forum will be fed into Habitat III – the 3rd UN Conference on Housing and Sustainable Urban Development – which will be held from October 17 to 20, 2016 in Quito, Ecuador.

The German Habitat Forum is one of the invitation-only conferences at this year's Metropolitan Solutions, but that will not stop its participants from networking with the participants of the other conferences and the exhibitors and visitors at the exhibition. The latter will include urban decision-makers – from municipally owned corporations to the real estate and local public transport sectors – and investors, providers of key services and solutions, NGOs, energy companies, urban planners and developers, research experts, government policymakers and representatives from all key technology industries.

Other conferences at Metropolitan Solutions 2016 include

- "Smart Cities" (organized by ICLEI, Local Government for Sustainability)
- "Urban Trends" (ICLEI, Euroforum)
- "Smart Country" (Bertelsmann Foundation)
- "European Second Cities" (EPSON – European Observation Network for Territorial Development and Cohesion)
- "Municipal Financing" (World Bank, European Investment Bank, KfW development bank, Euroforum),
- "Smart Options 2016: Energy Efficiency Yield" (green with IT), and
- "Clean, quiet: E-bus" (trolley:motion).

The conferences will focus on cities in Europe, America, Asia and the Middle East and deal with such topics as urban mobility, urban energy systems, architecture, urban planning, public spaces and city management.

For further information on individual conferences and the conditions for participation at Metropolitan Solutions, visit www.metropolitansolutions.de.

Mobility 4.0 – Quo vadis, Europe?

Preview: 15–17 June 2016 – European Transport congress & 90th anniversary of ÖVG, Vienna (AT)

The European Platform of Transport Sciences (EPTS) invites to the 14th European Transport Congress, held in Vienna. The Congress will be organized by the Austrian Society for Traffic and Transport Science (ÖVG). An overview of selected presentation speeches:

- Mobility 6.0 – Start thinking about the future
- Science Fiction "Moonshots" – or Pragmatism of Gradual Development?
- Horizons of Future Mobility: Which Strategy to Follow?
- Human factors in automated traffic
- Transport infrastructure requirements for Mobility 4.0
- Requirements for urban transport companies
- Digital infrastructures – opportunities for Mobility 4.0

More information:
www.oevg.at/veranstaltungen/events/2016/90-jahre-oevg/

8th Cities for Mobility Congress

Preview: 19–21 June 2016 – International congress on urban mobility, Stuttgart (DE)

The 8th International Cities for Mobility Congress titled "Mobility in the sustainable city: What do we need to do now?" will be held on June 19 to 21, 2016 at Stuttgart City Hall. The congress addresses municipal practitioners, decision makers, researchers and entrepreneurs from civil society and the private sector, combining presentations and workshops with practical activities, such as trainings and excursions.

The 2016 edition will focus on the linkage between mobility and urban planning when it comes to design and put into practice sustainable transport and active travel in cities. It also deals with the question of how municipalities can combine long-term planning (e.g. in infrastructure) with smaller and cheaper measures that are innovative, visible and easier to implement in urban space in the short term.

In addition, several initiatives from civil society and research will come together at the Cities for Mobility Congress in Stuttgart to bring in their ideas to support a change of mobility culture through awareness campaigns and pilots in public space. Some of these ideas will be presented in the workshop on mobility culture and in a small exhibition. Three workshops will take place in parallel on Monday, June 20, in the afternoon:

- Designing together the sustainable city: Successful connection of mobility and urban planning
- Making the new mobility culture quickly visible: Easy and innovative examples of mobility measures
- Mobility is our responsibility! The role and engagement of civil society and companies

One of the highlights at the Cities for Mobility Congress 2016 will be a cargo bike roadshow offered for participants, citizens and interested stakeholders from business, on June 20 on the market square at Stuttgart City Hall.

Congress attendance is free of charge. During the plenary sessions on June 20 and 21, simultaneous translation will be offered in English, Spanish and German.

The program along with practical information, registration and the call for posters is available on our website www.cities-for-mobility.net

Connected Car & Mobility Solutions

Preview: 29–30 June 2016 – ConCarExpo 2016 | International trade fair for connected car and mobility solutions, Düsseldorf (DE)

Car-to-X communication and connectivity between consumer electronics and the vehicle will sustainably change future mobility. With its new international trade fair ConCarExpo on June 29 and 30, 2016 in Düsseldorf, the German Engineers Association (VDI) is creating a targeted platform for this topic.

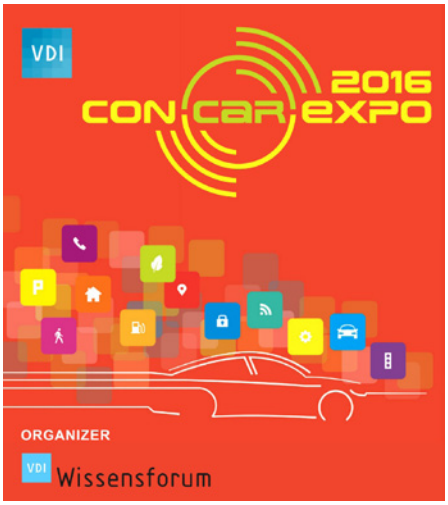
Under the motto "Connected Car & Mobility Solutions", car manufacturers, tier-1 and tier-2 suppliers, mobile phone companies and network carriers, internet providers, suppliers of traffic technology and government bodies will not only find the latest technical solutions but also new business models at the Messe Düsseldorf exhibition center, with the opportunity to exchange ideas and experience between different industries.

ConCarExpo will bring together specialists in automated driving and driver assistance systems, electronic components, software, infrastructure technologies, navigation, telematics, HMI and diagnosis, as well as mobility and development services and projects and initiatives for the traffic of tomorrow. Exhibitors will therefore address relevant customer groups without any coverage waste.

In addition to the trade fair stands, there will also be a high-level conference program, lectures by exhibitors and special car presentations to provide many possibilities for acquiring the very latest knowledge, establishing contacts and networking.

Within the framework of ConCarExpo, the prestigious CAR connect Award will be presented for the first time at the fair by the specialist magazine "connect": More than 12,000 participants voted for the best connected applications from car manufacturers.

VDI as an organizer with an extensive network of experts in automotive technology is supported by well-known industry associations such as the German Association of the Automotive Industry (VDA), BITKOM, ITS Deutschland and CVTA Connected Vehicle Trade Association from the USA. As part of this alliance, ConCarExpo is therefore the ideal meeting place for all those who want to know more about the connected car and play a key role in helping to shape its future.



More information and contact:
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www.concarexpo.com

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Dear Readers,

A little more than twelve months ago, in the 67th year of *Internationales Verkehrswesen*, the editorial team was preparing the first ever English edition of the long-established journal. The eMagazine was to be freely available for download, the print version was to be distributed exclusively at international exhibitions and congresses. This first edition was a kind of 'ballon d'essai': Will we be able to interest readers around the globe in this special magazine concept?

Yes, definitely: The present issue – *International Transportation* 1/2016 – is already the third of the series, made available again in electronic form for free download from our webpage at *www.internationalesverkehrswesen.de*.

It covers a wide range of topics: Automated driving, sustainability, or the provision of adequate mobility services in the most diverse settings are just some of the truly fascinating subjects discussed in the articles in this issue. The picture is rounded out by a differentiated view of the wide variety of transport solutions implemented in different regions.

The next issue of *International Transportation*, too, will explore these and other topics that characterize the rapid change in the transport sector and beyond. If you would like to contribute an article to a future issue of *International Transportation*, please contact us.
Or simply send me an e-mail to *eberhard.buhl@trialog.de*.
I am looking forward to hearing from you.

Sincerely

Eberhard Buhl, Managing Editor

CALENDAR OF EVENTS

18 May 2016 to 17 May 2017

18-20 May 2016 — Leipzig (DE)
International Transport Forum – 2016 Summit
Green and Inclusive Transport
Organization: International Transport Forum, Paris
Contact: itf.contact@oecd.org
http://2016.itf-oecd.org

31 May–02 June 2016 — Berlin (DE)
Metropolitan Solutions – Congress and exhibition
Create better cities!
Info: www.metropolitansolutions.de

15–17 June 2016 — Vienna (AT)
14th European Transport congress & 90th anniversary of ÖVG
Mobility 4.0 – Quo Vadis Europe?
Organization: European Platform of Transport Sciences (EPTS), Austrian Society for Traffic and Transport Science (ÖVG)
Info: www.oevg.at/veranstaltungen/events/2016/90-jahre-oevg

19–21 June 2016 — Stuttgart (DE)
8th Cities for Mobility Congress
International congress on urban mobility
Organization: City of Stuttgart
Info: www.cities-for-mobility.net

29–30 June 2016 — Düsseldorf (DE)
ConCarExpo 2016 – International trade fair
Connected car and mobility solutions
Organization: German Engineers Association (VDI)
Contact: info@concarexpo.com
www.concarexpo.com

20–23 Sept 2016 — Berlin (DE)
Innotrans – International Trade Fair for Transport Technology
The Future of Mobility
Organization: Berlin Fair
Contact: +49 30 3038 2376, innotrans@messe-berlin.de
www.innotrans.de/en

22–29 Sept 2016 — Hanover (DE)
66. IAA Commercial Vehicles 2016
New Mobility World logistics
Organization: Verband der Automobilindustrie e. V. (VDA), Berlin
+49 (30) 897842-0
www.vda.de
www.iaa.de/en

25-26 Oct 2016 — Abu Dhabi (AE)
NatransXpo – Exhibition & Conference
Future Transport Technologies & Smart Cities
Organization: Fleming Gulf Exhibitions
Contact: info@natrans-expo.com
www.natrans-expo.com

18–20 Oct 2016 — München (DE)
eCarTec Munich 2016
B2B Trade Fair for Electric & Hybrid Mobility
Organization: MunichExpo Veranstaltungs GmbH
Contact: info@munichexpo.de
www.ecartec.com

15–17 May 2017 — Montréal (CA)
62. UITP – Global Public Transport Summit
LEAD the TRANSITion
www.uitpsummit.org

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www.internationalesverkehrswesen.de

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The study will serve an important information source for existing and potential market players in the Scandinavian railway market and helps to adjust the strategic orientation of their own companies. As the study provides prognoses regarding the sales trends and the market attractiveness development for the Scandinavian railway industry, the interested reader is already now well-prepared to address the challenges of tomorrow and seize the related opportunities.

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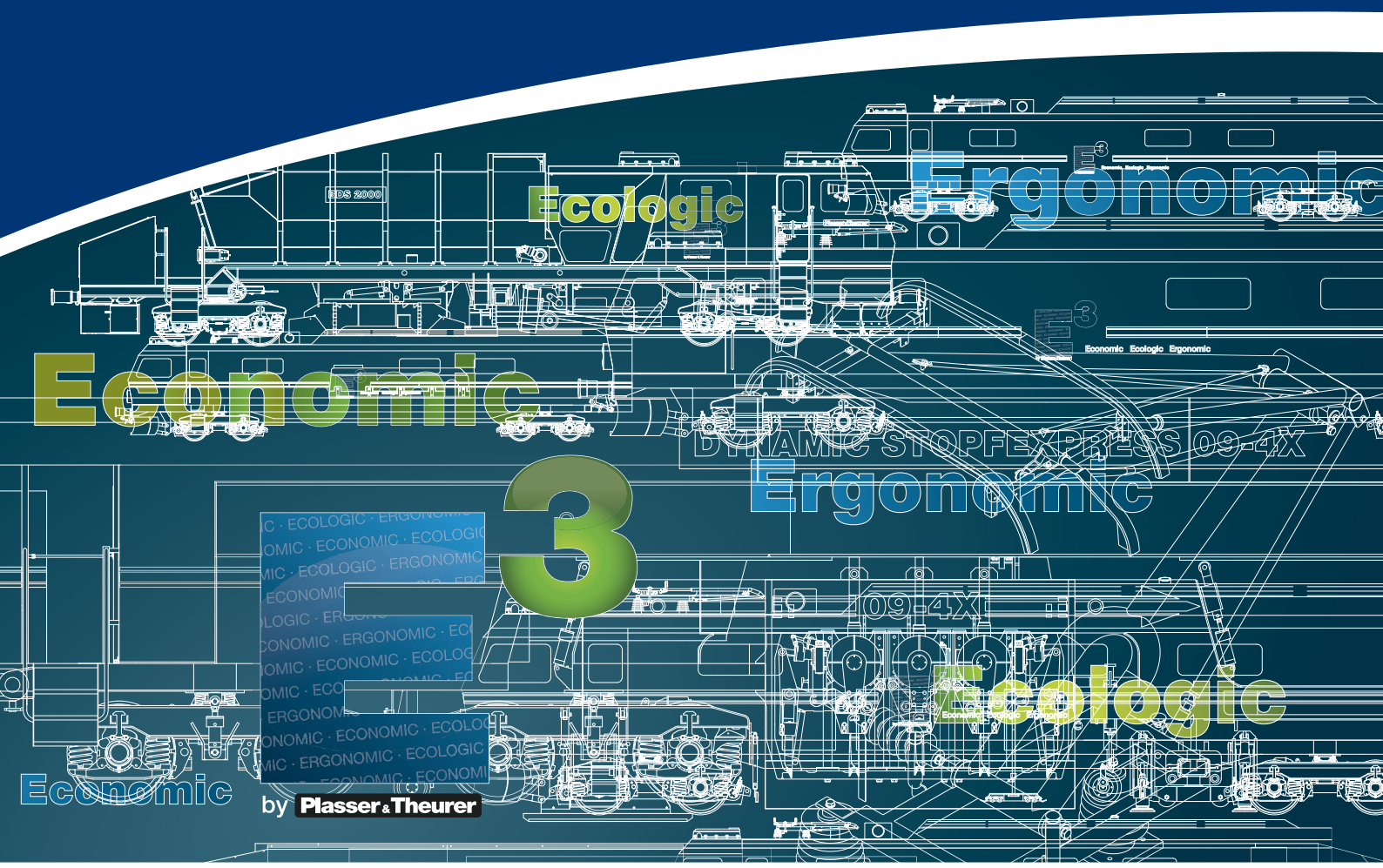

Economic Ecologic Ergonomic

The next step -

The Hybrid Machine