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# International Transportation

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Mobility in Europe – Challenges and chances

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## *Looking ahead*

**Advanced transportation solutions**

# Mobility in Europe – Challenges and chances

Every cloud has a silver lining. That's how I see the challenges facing our Transport Network in Europe. There are, however, many issues to be tackled.

The story of Climate Change is by now nothing new, and transport has to carry its fair share of the burden. Transport is responsible for around a quarter of EU greenhouse gas emissions making it the second biggest greenhouse gas-emitting sector after energy. Road transport alone contributes about one-fifth of the EU's total emissions of carbon dioxide ($CO_2$), the main greenhouse gas. In 2011, the EU committed to reduce transport emissions by 60 % on 1990 levels by 2050. As the Paris Climate Conference is edging closer, it is very important to revive an ambitious decarbonisation agenda. We need to internalise external costs and to disincentivise the least environmentally friendly forms of transport by adhering to the 'user pays, polluter pays' principle.

Congestion in the EU is often located in and around urban areas and costs nearly 100 billion EUR, or 1 % of the EU's GDP, annually. In a world where we are competing with economies globally, a 1 % reduction in costs for our businesses would be a huge advantage in competitiveness terms.

In addressing the issues of congestion and pollution, we face another challenge – that of the lack of investment. The European Union recognises that in order to meet the future needs of people and business, it is crucial that we invest, and invest strategically. We are therefore continuing with our vision to build the Trans-European Transport Network, more commonly referred to in EU circles as the TEN-T programme. The CEF funding mechanism is vital to this, and earlier this year, the first CEF call was announced, with funding to the value of 13.1 billion EUR for 276 different transport projects. However public monies alone will not be enough. Through President Juncker's 315 billion EUR Investment Plan, the Commission has put in place a plan to leverage private investment into a whole range of areas including transport.

Necessity is the mother of invention, and these challenges will provide new opportunities for mobility in Europe. One of the key growth areas, which I am prioritising, is Intelligent Transport Systems or ITS. The digitalization of transport will bring about many benefits. Firstly, there is a chance to develop new types of transport sector jobs, in areas such as research and development. Secondly, through increased automisation, safety will improve. Thirdly, new innovative mobility sharing services will be enabled, and reliability of services will increase. We must constantly ensure that we serve the needs of business and people. So how should we go about further developing ITS?

I see the need for protocols and standards in order to promote conditions for interoperability and co-modality. We also need regulation to ensure good market conditions, and attract investment. I propose we create four basic layers in ITS where standardisation and regulation can take place.

The *first* one is the infrastructure layer. We will need to equip our infrastructure to become a provider of data. Our transport infrastructure can be the source of rich data to be used in apps for the transport sector and beyond.

The *second* one is the data layer. As we move towards the internet of things we have to provide European standards for common or interoperable platforms. We have to keep an eye on standards developing internationally. The ability to collect, analyse and use data in a variety of ways will be crucial. Finding new mechanisms to share data will be equally important. We have an extensive transport network across all modes in Europe. I am convinced that transport can become a valuable source of 'data fuel' as the Commission continues its work to implement the Digital Single Market.

*Thirdly*, the applications layer: Once data is collected in a usable manner, we need to find a way to put it to work. As far as possible, we must aim to provide open and accessible platforms for developers to transform data into useful applications. ITS data can be used for a wide range of applications from signalling on our rail network, to traffic management and pollution control. Other examples include: timetable apps, accident reporting, information about delays and about alternative transport offerings.

*Fourthly* and finally, the services and solutions layer. Applications can then be taken to the next stage and turned into services and complete solutions for the end user. We can start concentrating on the 'Mobility as a Service' concept, and focus on passenger and companies using rather than owning modes of transport. There are many opportunities going forward, with the possibility in of a one-stop website to book all transport – regardless of mode. There is the chance to create a single on-board unit for all road-charging across Europe with one single bill for the end user. We will have the opportunity to really see connected mobility and ultimately driverless cars.

I suggest that we use these 4 core horizontal layers for standardisation and regulatory framework for ITS. If we get these layers right, we will make good progress in ITS.

Although there are many challenges, I am confident that if we put the right framework in place, we will be able to meet those challenges head-on. I am confident that new opportunities will outweigh the challenges, and lead us to a bright future for mobility in Europe.

**Violeta Bulc**,
Member of the European Commission in charge of Transport

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International Transportation



# POINT OF VIEW



# STRATEGIES





# BEST PRACTICE



# CONTENT

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## PRODUCTS & SOLUTIONS



INTERNATIONAL TRANSPORTATION 1/2016

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## SCIENCE & RESEARCH



## COLUMNS

Photo: Daimler AG

# Back to reality!

## The future of autonomous cars

Driver assistance, self-driving cars, road transport, urban transportation

The decades-long evolution of driver assistance systems in road vehicles will doubtless continue in the future – particularly with regard to passenger safety. In this context it may be possible to achieve driverless movement to a certain degree and under specific structural and traffic-related conditions. Taking into account the reality of the road transport environment and the resulting technological limitations, an approach based exclusively on autonomous cars is fundamentally misleading. It is not justifiable at all, in particular regarding aspects of safety, security and ethics.

Author: Andreas Kossak

For years now, forecasts, scenarios and daydreams, development activities, fairs and congresses as well as articles in scientific journals, magazines, newspapers and even in the "yellow press" have been revolving around the imminent drastic changes in individual motorized mobility – catchword: autonomous cars. Some examples:

- The transport system concept that won the "Smart Cities Audi Urban Future Award 2012" is based primarily on autonomous vehicles and automated guideway systems [1] (*figure 1*). The transport system of 2014's award-winning concept is similar. Comment of Audi CEO Rupert Stadler: "The mobility revolution is the great field of opportunity for the 21st century" [2].
- Scientists at renowned US universities (MIT, Stanford) conducted modelling-based calculations regarding the substitution of all motorized personal traffic (including transit) in the centers of metropolises by "Robotaxis". According to the case study for Singapore, about 250,000 such vehicles would be needed. However, the average travel time during the rush hours would double, compared to the "conventional" system [3].
- The investment bank Morgan Stanley published a "Blue Paper Autonomous Cars: Self-Driving the new Auto Industry Paradigm". In this paper it is predicted that "Suburbanization" will be a future megatrend, because when people can do other things while they drive, more of them will live further from the denser parts of urban areas. That is the com-

Figure 1: Vision of urban mobility – "Audi Urban Future Award 2012" Quelle: [2]

plete opposite to the megatrend "Urbanization" that sociological discussions hitherto tend to focus on [3].
- According to numerous "future and mobility researchers", the privately owned car will soon be termed a fossil, because it will be fully replaced by the sharing of conventional or autonomous cars [4, 5].
- The software giant Google announced having developed a fully autonomous car and to be looking for an industry partner for mass production [6].
- The German DOT stated that it fully supports the "development of autonomous driving" [7].
- At the "Consumer Electronics Show" (CES) in Las Vegas in January, several German automobile manufacturers presented their concept vehicles for autonomous driving. A slogan at the conference claimed that, "Self-driving cars are the next big thing" [8].

In various scenarios regarding the future of mobility, people will need neither a car of their own nor a driver's license to use autonomous cars/vehicles/Robotaxis in order to nominally serve any mobility demand in cities as well as in rural areas at any time and even much better than today. The euphoria in this context is founded on the one hand on statements of technology- and marketing-oriented representatives of the industries involved, and on the other hand on the conviction of self-appointed experts, who are fascinated by the supposedly unlimited technological possibilities. From the camp of qualified independent experts, however, increasingly critical voices addressing the manifold hard limitations of operating autonomous cars in the reality of (in particular urban) road transport are making themselves heard [3].

## Basics

The idea of a road transport system that is based on autonomous cars is far from new. In the late 1950s, for example, stories about "cars of tomorrow" able to drive completely autonomously were in full vogue (*figure 2*). More than 50 years later, at the 2015 CES, manufacturer Daimler presented a study that looked remarkably similar to the "historical" one – except for the different leisure activity of the passengers [9] (*figure 3*).

The decisive difference is that since the 1950s there have been some far-from-completed, but very useful developments in the area of driver assistance tools. That progress is expected to advance much further in a very short time, resulting in fully autonomous cars. However, this extrapolation neglects fundamental facts. The possibilities and limitations of autonomous cars/road vehicles can only be described realistically if we define the fundamental characteristics of the road traffic system on the basis of the empirical sciences:

*Modern settlement and traffic structures are infinitely complex systems that are continually changing as a result of infinitely complex processes.*

This is in particular the case in urban areas. By definition, such systems can only be modelled within very narrow limits and cannot be comprehensively controlled by technological means. Robert Poole, one of the leading transport researchers in the US, has his own take on this issue. The co-founder and Director of Transport Policy of the Los Angeles-based Reason Foundation, recently summarized his conclusions of some related expert discussions [10, 11, 12]: "...while I see significant potential, the more serious literature I review, the more skeptical I become about the popular media hype of cars without any function for a driver, going anywhere on demand. [...] Let me summarize the main points raised by this collection of experts, as follows:
- Automation is inherently brittle and subject to failures.
- Hence, for at least a long time, a driver must be able to take over on short notice.
- We don't really know how to provide such transitions, and the aviation experience is troubling.
- There are ambiguous situations where we may not want the automation to make the decisions."

## Selected aspects

### *Limited control*

As a consequence of "infinitely complex" boundary conditions, mastering the autonomous vehicle concept will be possible only to a very limited degree, even if we presuppose a further massive progress regarding programming and computer capacities. That is why qualified insiders, with good reasons, are marking the limits of the practicability of autonomous cars as follows: "Cars are only able to select from what the programmer has defined" [13].

In particular in cities, cars are closely integrated into a complex multimodal traffic environment. The behavior of pedestrians, cyclists, children and elderly people in such an environment cannot be modelled to an even remotely comprehensive degree by a computer. Even the strongest advocates of maximally autonomous cars/vehicles concede that such systems are susceptible to failures – the more complex the configuration, the higher the probability of malfunctions.

### *Traffic safety and ethics*

The development of driver assistance systems focuses on improving traffic safety, among other things. A representative of

Figure 2: Driverless cars of the future in an advertisement for "America's Electric Light and Power Companies"
Source: Saturday Evening Post, 1957. Credit: The Everett Collection

Figure 3: "Autonomous driving with Daimler" – cars of tomorrow in 2015 [9]
Photo: Daimler AG

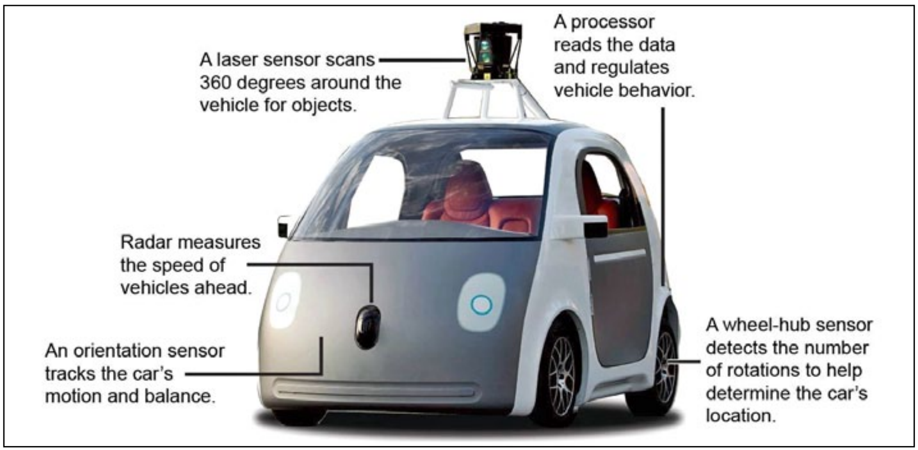


Figure 4: The Google concept vehicle for autonomous driving Source: Google/Raoul Rañoa

Volvo, a company manufacturing cars that are traditionally known as being extraordinarily safe, recently underlined the company's vision that "by 2020, no one should be killed or severely injured in a new Volvo car" [14]. That sounds good; however, it obviously pushes aside answers to fundamental ethical questions in this context, such as:

- Who decides about the risks for people being involved in an unavoidable accident?
- How should car manufacturers decide how to weigh up the deaths of people sitting in other manufacturers' cars against the risk for people sitting in one of theirs?

While the general public is fascinated by the supposedly unlimited technological potential to reduce the number of car accidents and of accident victims to "nearly zero" and therefore concludes that society is ethically bound to implement a comprehensive system of fully self-driving cars [6], the position of qualified independent experts looks completely different: "But no technology is perfect, especially something as complex as a computer, so no one thinks that automated cars will end all traffic deaths. Even if every vehicle on the road were instantly replaced by its automated counterpart, there would still be accidents due to things like software bugs, misaligned sensors, and unexpected obstacles. Not to mention human-centric errors like improper servicing, misuse and no-win situations [...]" [15].

As recent studies of renowned academic institutes have revealed, it is anything but certain that autonomous cars will ever make road transport safer. In particular during the transition phase (mixed traffic) of at least 20 years, the safety standard will even be substantially lower than today [16]. In this light the question must be raised if the whole approach can be justified at all.

***Vulnerability***

Transport infrastructure is a fundamental function of our settlements and our economy. This is particularly true for the road sector. Consequently, this infrastructure is of high interest to criminals and thus highly susceptible to criminal activity, as well as to "experimental" cyber-attacks. Digital worlds are (and will be in the future as well) vulnerable to manipulation by hackers, internet criminals and terrorists. As a consequence, a road transport system based on autonomous cars is much more vulnerable than the "classical" system.

***Legal questions, standardization, interoperability***

The ethical aspects of traffic safety within a system of autonomous automobiles are closely related to legal questions. This is true for virtually all components of traffic law. It is unlikely that even the key problems in this context will be solved in an acceptable and conclusive way. What happens, for example, in case of a cruel accident that is not caused by any person [14]?

Our automobile transport system is composed of vehicles of a great variety of types and makes supplied by an international industry. The share of the transport performance of foreign (licensed) heavy trucks using Germany's motorways, for example, amounts to about 30 %, the share of foreign licensed cars to around 5–10 %. Hence, a complete system based on autonomous automobiles would presuppose a degree of international standardization and interoperability that would be far more complex than the highly complicated compendium of laws and regulations in force today.

Anybody familiar with the related problems within the European Union alone, will easily come to the conclusion that it will take not just years, but decades, to define and put into effect the required basic laws and regulations for the large-scale operation of completely autonomous road vehicles in Europe.

***Structural conditions***

Among the main drivers behind the development of autonomous road vehicles are manufacturers and research institutions in the USA. That is not least due to the specific conditions that characterize American urban areas and highways [4]:

- The width of the roads in most cities is "comfortable" and the road networks are mostly designed as a rectangular grid, often with a comprehensive one-way regime.
- Interurban road traffic typically involves very long distances on limited-access highways.

Taking that into account, the conditions for the selective application of road vehicles being equipped with a large arsenal of driver assistance devices, and thus being able to drive autonomously under certain conditions, are by far better in the US than in Europe. Still, skepticism is growing even in the US.

***Costs***

Today the costs of equipping a car with the devices necessary to allow driverless travel under special conditions are several times higher than the costs of a car with conventional driver assistance systems [5] (*figure 4*). Even if we consider that mass production will considerably lower the costs of the different components, the costs would most probably still exceed the amount acceptable for the majority of car owners, especially in view of the limitations on use of the driverless mode in real-world traffic. Only if many, most, or even all autonomous cars are provided by a public or private operator and the individual vehicles are actually used 10 times on average or even more than a privately owned car, the operating costs for a trip may be acceptable.

***Privacy etc.***

Privacy concerns are some of the main obstacles standing in the way of automatic road toll collection. How will it be possible to ensure privacy in a world of autonomous cars? What about serving the greatly varying requirements of car users regarding size, comfort, space for luggage, and all their other personal preferences? Large-scale car sharing schemes will raise questions of hygiene and cleanliness. And how do we plan to combat vandalism and robbery, which have been increasing in the motor vehicle sector for decades?

***Substitution of transit***

The question if public transit services will be replaced by autonomous cars was on the agenda of last year's annual meeting of the Transportation Research Board (TRB) of the US National Academies of Sciences. Even autonomous-car enthusiasts argued in favor of substituting classical public transit by autonomous vehicles only to the limit of complementing public transit in by-demand areas. The result would be some kind of advanced variant of "Paratransit" [17]. However, even in that regard several questions remained unanswered: What about passengers needing special assistance? Who are the owners and who are the operators?

**Conclusion**

The decades-long evolution of driver assistance systems in road vehicles will continue without any doubt – particularly with regard to passenger safety. In this context it may be possible to achieve driverless movement to a certain degree and under specific structural and traffic-related conditions. Taking into account the situation in Europe, this could be possible first and foremost only on limited access roads outside urban areas. In the foreseeable future, autonomous motorized personal transport will not and should not substitute classical motorized road transport or even substantial parts of it, in particular in urban areas.

The individuals and organizations in charge of planning and managing road transport are well advised to rely on the point of view of independent qualified experts in this regard and to concentrate on taking full advantage of the huge not yet utilized technological potential of improving the classical systems. This refers in particular to payment, information and communication systems covering the entire transport sector and related markets as well as to optimizing operations in multimodal traffic environments and the operation of "autonomous rail systems". ■

**REFERENCES**


[1] Audi AG: Audi Urban Future Award 2012; in: Die Welt, special issue "Smart Cities", October 20, 2014

[2] www.audi-urban-future.com

[3] Poole, R.: Progress – and more Questions – on Autonomous Vehicles; in: Surface Transportation Innovations, May 2014

[4] Kossak, A.: Zur Zukunft des Stadtverkehrs; in: Der Nahverkehr 10/ 2014

[5] Wikipedia: Google Driverless Car; accessed on September 8, 2014

[6] Stein, H.: Wir Automobil Barbaren!; i: Welt am Sonntag, December 14, 2014

[7] Bundesministerium für Verkehr und digitale Infrastruktur: Info-Papier "Automatisiertes Fahren"; Berlin 2014

[8] Grünweg, T.: Kräftemessen der Autopiloten; in: Spiegel Online, January 6, 2015

[9] sv/sp-x: Lenkrad? Wozu denn? So sitzen Sie im Mercedes von morgen; in: FOCUS Online, January 4, 2015

[10] Cummings, M.L. and Ryan, J.: Who is in Charge? The Promises and Pitfalls of Driverless Cars; in: Transportation Research News, May/ June 2014

[11] Hutton, P.: A Driverless Future? in: Thinking Highways, North America Edition, 2/2014

[12] Poole, R.: Important new Thoughts on Autonomous Vehicles; in: Surface Transportation Innovations, November 2014

[13] Pritchard, J.: Die Crux selbst fahrender Autos; in: Hamburger Abendblatt, November 25, 2014

[14] dr/SP-X: Das chauffieren ohne Chauffeur könnte Jahre dauern – zumindest in Europa; in: FOCUS Online, November 20, 2014

[15] Lin, P.: The Ethics of Saving Lives with Autonomous Cars is Far Murkier Than You Think; published on: wired.com, July 30, 2013; http://www.wired.com/2013/07/the-surprising-ethics-of-robot-cars/

[16] N.N.: Autonomous vehicles may 'worsen safety'; in: ITS International January/ February 2015, p. 7

[17] Badger, E.: What will happen to public transit in a world full of autonomous cars; in: The Atlantic Citylab, January 17, 2014



**Andreas Kossak**, Dr.-Ing.
Kossak Forschung und Beratung,
Civil Engineering Lab, Hamburg (DE)
**drkossak@aol.com**

# "Highly automated vehicles are not built for their own sake."

Self-driving cars are certainly in vogue. They are one of those technological developments that analysts reckon will have great market potential across the world. But what do vehicles actually need to make their independent way through the streets of the world? How far have we come? And how quickly are we going to have to get used to swarms of "robot cars"? These are some of the questions International Transportation asked Dr. Martin Birkner, Marketing Manager Automotive Sector at Here, Nokia's mapping service.

**Dr. Birkner, some users know the name Nokia Here from the mapping service provided on their Windows smartphones. But after the announced takeover by Audi, BMW and Daimler, automobile manufacturers suddenly seem to be showing serious interest in your products and services. What's behind it all?**

For a start, we have been working closely with the automotive industry for decades, right across the world. The automotive industry has confidence in us, and we continue to make a contribution to our customers' success through innovation, quality improvements and product enhancements. In Europe and the USA, you will find our maps in four out of five cars that have built-in navigation systems, and as far as traffic information goes, we have the world's largest coverage with Here Real Time Traffic, our traffic information service that offers 100 % road coverage in 50 countries.

The reason for the even greater interest in our business is the fact that the 'maps' that we use in our navigation system these days are currently going through a fundamental transformation. As part of the trend towards digitization and connectivity, these maps are being converted into something that we call the 'Here Location Cloud'. In the future, this cloud will be a central component for the vehicle connectivity and for all of the underlying business models for infotainment and navigation in the context of highly automated driving or even autonomous driving. The Here Location Cloud consists of three components and provides the functions that will be essential for the automotive companies to strengthen their competitive position.

**What components are these?**

The first component includes what we have been doing since Nokia took over Navteq in 2008. We measure the world. At that time the focus was on the creation of 2D maps, whereas today we are working on 3D and developing high-resolution maps, so-called HD maps, which can be accurate to within ten centimeters. A major contribution to the development of these HD maps has been our fleet of around 200 vehicles, which are constantly travelling the world's roads, capturing highly accurate mapping data. High-resolution mapping – effectively indexing the world – stimulates the imagination, of course. Suddenly we understand exactly where objects such as road markings, bridges or road exits are located, and can pass this information on to the equipment. This is of central importance for highly automated driving. We are already working on projects in this area with leading partners in the automobile industry.

**In other words, with nothing more than your maps you would be able to tell a car if it is correctly positioned in its lane?**

That's right. Lane accuracy is one of the central elements of our HD maps. In conjunction with the vehicle's technical systems, we can tell exactly where the vehicle is positioned on the highway – for example, whether in the left lane or in an exit lane and help fine-tune the driving strategy of a highly automated vehicle so that it is safe, efficient and enjoyable. In the medium term this will be essential for highly automated driving, but it is also useful today for what we call 'Smart Guidance'. Current GPS navigation devices are sometimes not sufficiently accurate to precisely display the traffic as it actually is. Based on some recent innovations in traffic guidance data provision ('Split Lane Traffic') and our HD maps, we will be one of the first companies on the market to bring this accuracy to dynamic services, such as traffic guidance, and make it available to our customers.

For this purpose, the second component is extremely important: the so-called 'dynamic data layer'. It is not enough to know exactly where things are. We also need to know precisely what those things and people are actually doing and how they move and change. Every movement and every incident – such as an accident – creates dynamic data, which in turn influences other road users. Across the world, millions of road layouts are permanently changing, and we must therefore constantly adapt our maps, so that we can tell the car that it is located on the turning lane to the right, and next to it is a fire hydrant. But of course there are even more important pieces of information, for instance that traffic has come to a halt 50 m ahead, requiring the car to immediately adjust its speed. All this is the so-called dynamic data layer.

The dynamic data layer becomes progressively more effective when more data is provided by additional vehicles and other sources. We have therefore recently recommended to the car industry to define and introduce a standard interface format so as to provide sensor data from vehicles on maps in a uniform manner. This would enable us to further improve the foundations for the dynamic data layers.

**Can this not already be achieved using radar sensors?**

Sure, in theory, a car could do that today, if the conditions are right. There have been pilot tests, such as cars driving across the US, from the West Coast to the East Coast, using data from the vehicle's own sensor system. However, these are test vehicles – for the wider market that will not work, for a variety of reasons. Highly automated driving must not remain an application that is limited to just a few high-end vehicles. We must all implement this technology on a global scale so as to fully tap the benefits of highly automated driving, as there are:

fewer vehicles on the roads, more efficient road transport, less pollution and a better driving experience for people travelling from A to B. This can only be achieved if we combine a vehicle's sensor system and computing capabilities with the dynamic services offered by the cloud. Dynamic services such as predictive traffic information can then be used to inform the vehicle – or the driver and the passengers – as early as possible of any decisions that need to be taken. This will help to reduce the stress that we sometimes experience in today's traffic, and pave the way for highly automated driving.

Dr. **Martin Birkner** has over 17 years of experience in strategy and product development in the areas of connectivity solutions and applications in the automotive industry, smart grids and telecommunications. For more than eight years he was a consultant in the telecommunications industry, and later worked for Robert Bosch GmbH, Telefónica, and frog design. Today Dr. Birkner is responsible for global product marketing in the automotive sector at Here.

**Don't you expect any difficulties to arise between connected and non-connected driving during the transitional period?**

To be honest, no, I don't see any major difficulties, because this is an issue that is already playing out on our roads, albeit in a restricted form. In a sense, connected vehicles have been around for some time already. Their drivers have access to dynamic traffic information, such as constantly updated congestion information displayed on their navigation devices, which enables them to adjust their driving behavior at an early stage. At the same time, other drivers respectively their vehicles are not connected in any way. We are already able to see that with about 15 to 20 % of vehicles in a given geographical transport area being connected, traffic becomes much more efficient, less stressful and more environmentally friendly for all involved.

The question is more of an issue in really chaotic urban transport situations. In fact, we are not just talking about the highways in Germany or Switzerland here, but also about mega-cities in China, South America, Africa or India, where completely different traffic conditions prevail. In such places, the transitional phase could possibly be eased by the city council or the government allocating only specific routes for highly automated driving, ideally in cooperation with the automotive industry. Perhaps this could be done temporarily and for individual road stretches only, depending on the section-specific risk level assessed on the basis of traffic volume, time of day or indeed the current weather.

**How do you see that working out?**

Using our map data in combination with our dynamic services that provide information about the current traffic situation, the next 20, 40 or 100 km on a particular section of road, such as a motorway, can be analyzed. Then dedicated algorithms can be used to calculate the risk. Depending on the result, permission for highly automated driving can be granted to connected, highly automated vehicles over a defined stretch of road.

**So here we are talking also about data coming from the road infrastructure?**

Absolutely. We go for cooperation with all the major players in the field of Intelligent Transportation Systems (ITS) in order to incorporate data from traffic lights etc. Highly precise map data, information provided by the infrastructure, data from the vehicle, as well as insights about driving behavior – the combination of all types of data is what makes the Location Cloud so useful. By aggregating and analyzing all this data, we know exactly what's out there, we also know how the situation is changing dynamically at this very moment, and we can draw conclusions about how the situation is likely to develop in the next half hour.

**Now the fascinating question is this: What happens with all this information?**

Here we're talking about the third component, the Location Cloud. This component makes it possible to offer all of these functions and data in an appropriate form to third parties who either want to use them for business – for example to sell cars or handsets – or who, as end users, need the data and functionality for driving purposes. For these uses, we make the various delivery capabilities of our platform available. Access to this combination of high-resolution maps plus dynamic adjustments is possible either via an Application Programmer Interface (API) or a Service Development Kit (SDK), enabling companies such as automakers to integrate all this data quickly and easily in their own products and innovations in a suitable form. This helps shorten the time to market and dramatically boosts our customers' capacity for innovation. Until now, innovation cycles usually lasted three to five years. Now they are at under three years – if, in view of the current speed of digitization, we can still talk about innovation cycles at all.

Moreover, with Here Auto we offer a complete end-to-end navigation solution for the automotive industry, which makes our Location Cloud not only available for use in the vehicle, but also on a smartphone. This is one of the first solutions on the market that accompanies the drivers on their entire journey from A to B – not merely in the car, but also when outside the vehicle. For example, Jaguar recently featured Here Auto in the new Jaguar XF launched this year, where it forms the basis for their navigation solution. This allows the total journey to be planned on a smartphone even before getting into the car, accompanying the driver with useful information during the drive itself and then again on the smartphone over the final phase of the trip.

**And how does this work?**

In the medium term, for example, the smartphone can advise the user to start half an hour earlier in order to avoid a traffic jam – or better still, set off half an hour later, because then, according to the data, the congestion will have dispersed. If you think this through and place this scenario in a net-worked, urban environment, you suddenly discover a range of possibilities for optimizing the entire traffic flow using such applications. This does not only benefit the end users, who will reach their destinations faster, more efficiently and in greater comfort, but the cities as a whole as well.

**What you have just said about the opportunities such systems offer to the user inevitably leads to the issue of security. In practice, privacy no longer exists when, from dawn to dusk, virtually all our actions, movements and plans are stored in the cloud. And aside from that, any electronic system can be hacked.**

It will probably never be possible to offer one hundred percent security, but when it comes to our systems, you must distinguish between anonymous and personalized data. The connection of the driver, the vehicle and the passengers is carried out in completely anonymous form. The data is stored in our OEM customers' protected, highly secure data bases, and none of the data transactions and analyses carried out within the cloud to provide the desired services are based on personalized data.

Decentralization is also one of the key principles that will govern the cloud in the future. The 'Silicon Valley' approach of using centralized and personalized data in a cloud in the context of the "Attention Economy" to foster sales in the automotive industry is completely contrary to the way that we see things. We see ourselves more as a 'steward' of the data, and agree business models under license that do not require any further monetization of the data to become profitable.

Another principle is the protection of data integrity. Just think of the various events that have occurred recently, where vehicles were taken over and controlled remotely from the outside: Such nightmare scenarios, where the driver has no way to stop the vehicle or to get out, are precisely the reason why the automotive industry needs to create its own cloud aimed at securely protecting all those sensitive data ...

**... that means a cloud that is not accessible via a smartphone?**

We must not forget that smartphone operating systems like Android were never designed to enable business-to-business transportation systems. In the various versions of Android there are an incredible number of loopholes that have still not been closed. That is why you must not link safety-related systems in a vehicle with any infotainment and navigation systems.

## BACKGROUND INFORMATION

### About Here

Here is a Nokia subsidiary. It brings together the expertise in the fields of mapping and development of location-based services that Nokia has systematically built up since the mid-2000s. Some of the decisive steps in its development included the acquisition of gate5, a Berlin-based navigation start-up, in 2006; of Navteq, which was founded in 1985 and is the world's largest developer of digital map data, in 2008; and of earthmine, a specialist in 3D cartography and street panoramas, in 2012.

Here has existed as an own brand since the end of 2012 and supplies customers from the automotive industry, the enterprise sector and the retail business with maps, location-based services and location intelligence.

In August 2015, Nokia announced its intention to sell Here to a consortium consisting of Audi AG, BMW Group and Daimler AG. The sale is expected to be closed in the first quarter of 2016.

**Could you please give an example?**

First of all, the HD map is nothing more than a data cloud consisting of individual data points, which can be equally used as input for infotainment systems as for the development of driving strategies for highly automated driving. These applications must simply be run separately from the earliest possible stage. It must be impossible for a consumer navigation app or a service app to interact with the vehicle system in such a manner as to gain access to safety- and driving-related areas. We at Here already have comparatively many years of experience with such business-to-business IT systems, as we call them, because we provide similar products to the public sector, to governments and administrative departments. For us, one thing is clear: The solution can only be a standalone cloud for mobility applications such as highly automated driving.

**In other words, what we heard some time ago about seizing control of automotive electronic systems was, in a sense, a shot across the bows?**

You are right. I guess that was just the warning shot that we needed, because in the past five years we have seen tremendously rapid growth in the field of vehicle connectivity, and the system security functions really need to keep pace. But development is continuing apace. In the automotive sector we have the relatively secure GSM/UMTS air interface, which is being further refined precisely because of constant attacks by hackers. At the same time, operating routines must be developed that are able to detect an abusive intrusion and react in a way that will prevent anybody from getting hurt and also minimize potential economic losses. I'm convinced that it is possible to place safety-relevant and personalized data behind a firewall that will be secure enough to create one of the safest IT systems anywhere – and we are talking about a system that, in 10 or 15 years, will be used in millions of vehicles across the world.

**So let's just keep looking into the future for a moment. Can highly automated driving already be implemented in practice?**

Technically it is doable. The open questions relate more to regulatory issues, i.e. the political and normative standards, and to its economic viability. Highly automated vehicles are not built for their own sake. The end consumers really have to find such a system so attractive that they are prepared to invest more than they would for a conventional vehicle. Furthermore, we must not forget that all these vehicles have a certain lifespan. They will have to be constantly updated over their lifecycle in order to reflect current state of technology, safety and security solutions, and at some later point, they will be discarded. New service structures must be created for this, which on the one hand takes time and on the other requires a certain level of market penetration.

That means that we will see a gradual development in market penetration, via several degrees of autonomy, until truly autonomous driving will be achieved far in the future. Actually, I do not like the term 'autonomous driving'. In practice a vehicle is certainly not able to act completely independently, i.e. 'autonomously' in the literal sense. It is always dependent on the infrastructure and must obtain information about the road conditions and its surroundings.

**Nevertheless, there are more and more ideas for corresponding uses around, such as autonomous mini taxis picking up the elderly to take them shopping. How realistic is that?**

The advantages of such vehicles would be enormous, particularly in an aging society, because such services could reintegrate a significant share of the population into social life. In a completely measured and charted environment – such as in Cupertino in California – that is actually working well. However, in the normal road traffic in today's cities, I consider the prospect of any general deployment of such applications to be science fiction for the time being. ■

# Traffic flow at the entrance to the Baltic Sea

## The Kadet Trench: maritime traffic flow and its parameters

Vessel movements, traffic flow, traffic volume, congestion

Navigation in the Baltic Sea is challenging, mainly because of its relative shallowness, the ice cover in wintertime and the narrow navigation routes. The present paper focuses specifically on the Kadet Trench (KDT), which provides the only deep-water access to the Eastern Baltic. The trends in ship sizes and speeds in the Kadet Trench are monitored through the collection and evaluation of AIS data for the years 2009 to 2014. Moreover, the paper offers an analysis of the composition of the traffic flow and the hourly and weekly fluctuations of traffic density.

Authors: Nina Vojdani, Manfred Ahn, Frank Hartmann, Carsten Hilgenfeld

In 2012, around 9.1 % of total volume of international seaborne cargo was handled in the ports bordering the Baltic Sea [1, 2]. The Kadet Trench (KDT) represents the only deep-water entrance to the Eastern Baltic (see *figure 1*). The other entrance to the Eastern Baltic, i.e. the Öresund strait between Denmark-Copenhagen and Sweden-Malmö, is limited to a navigable draft of 8 m. There are further smaller belts and sounds in Denmark that remain non-navigable for merchant shipping due to their insufficient draft [3]. Thus the Kadet Trench with its navigable draft of 16 m and its geographical proximity to the German Baltic Sea as well as to the Kiel Canal (North Sea – Baltic Sea) is primarily used by ferries, tankers and feeder vessels in order to call at diverse ports along the Baltic Sea. The transport volume in the Baltic Sea is expected to grow in the future.


Figure 1: Entrance to the Eastern Baltic Sea
Source: openseamap

### The Kadet Trench

The research area includes the KDT, where traffic is controlled by the Traffic Separation Scheme (TSS) "South of Gedser." The west side is geologically limited by the Danish Falster Island and its extensions of the Gedser Reef. The inshore traffic zone "Fischland" was established in 2007, to the south and east of the TSS. *Figure 2* shows the ship trajectories within the KDT: Paths used only once are represented in white. The more often a trajectory has been used, the darker the color. This color scheme makes the main shipping routes of the TSS visible. At the same time, a number of shipping trajectories that are not part of the TSS traffic flow are revealed.

For the analysis, the research area is projected in a square format, with buoy W 71 of the Gedser Reef as the most south-western point and buoy E 72, marking the inshore traffic zone, as the most north-eastern point. This area is divided by the buoys 71 and 72, whose distance is 3.66 sm or 6.78 km from

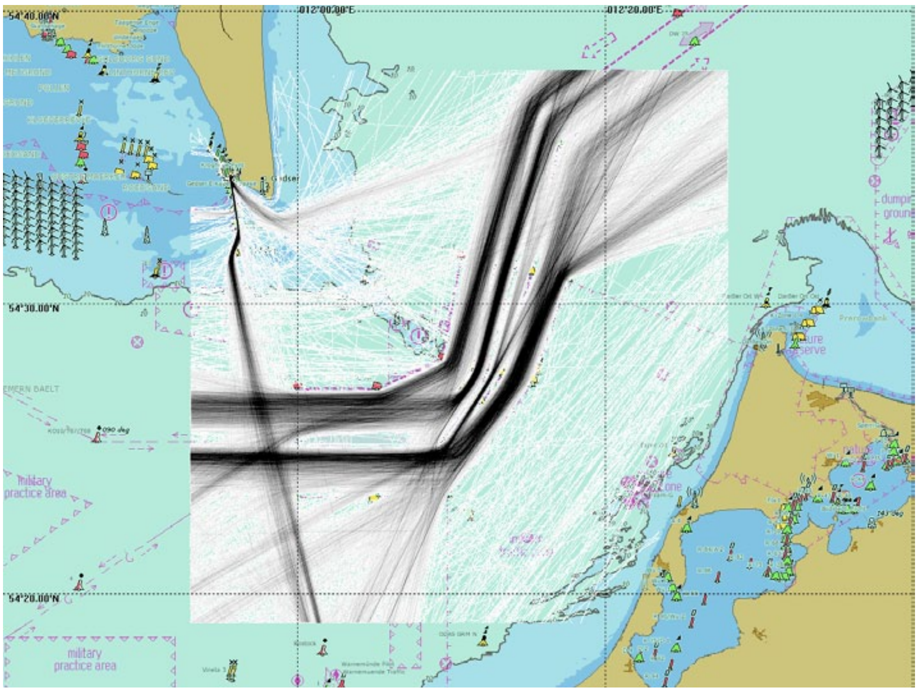


Figure 2: Ship movements in the KDT
Source: Trajectory data overlay on electronic sea chart

each other (see *figure 3*). On the west side, ships navigate southwards, and on the east side, ships sail northwards. Both shipping directions are additionally subdivided into shallow-water (outside) and deep-water areas (inside). According to an IMO recommendation, ships with a draft of more than 13 m should take into consideration additional security measures such as taking a pilot on board for this passage [4].

### Data basis

The analysis is based on Automatic Identification System (AIS) data supplied by the Federal Waterways and Shipping Directorate (WSV). The AIS is a broadcast radio method, based on the ITU recommendation ITU-R M.1371-5, for the transfer of codified information [5]. The standard was confirmed by the International Maritime Organisation (IMO) in the year 2000 and the AIS regulation was integrated in the International Convention Safety of Life at Sea (SOLAS). The method offers detailed information on ships as well as their cargo in order to allow onshore traffic control by the respective coastal state, and thus aims primarily at avoiding ship collisions and increasing security at sea.

The data were obtained via the official channels from the WSV, which functions as the official directorate since 2011 [6]. The data base excerpt shows a special data editing format so that it had to be converted in a first step. For a more extended overview of the situation, the available time frame from 03/2010 to 12/2014 of the WSV data base was complemented by earlier AIS data covering the time span from 01/2009 to 2/2010 obtained from the Department of Maritime Studies at the University of Applied Sciences Wismar. The low net coverage resulted in a low quality of the data, especially with regard to the northern part of the Kadet Trench, so that the data from 01/2009 to 02/2010 by themselves were inadequate for a full representation of the overview of the situation. Consequently, these data were only used to provide information of speed and dimensions of the ships.

### Evaluated data

For the preparation of the analysis, the AIS data were filtered and stored in a suitable project data base. This data base contains the static and dynamic information of all ships that belonged to the traffic flow of the KDT. The data on vessels that were present in the concerned sea area but were not part of the traffic flow were deleted. This included for instance those ships present in the KDT that only crossed the TSS, fished in the TSS or simply touched the TSS [7]. The primary aim was to create a data base containing all relevant vessel data in order to enable an analysis of all vessels that were located in the area and followed the traffic route.

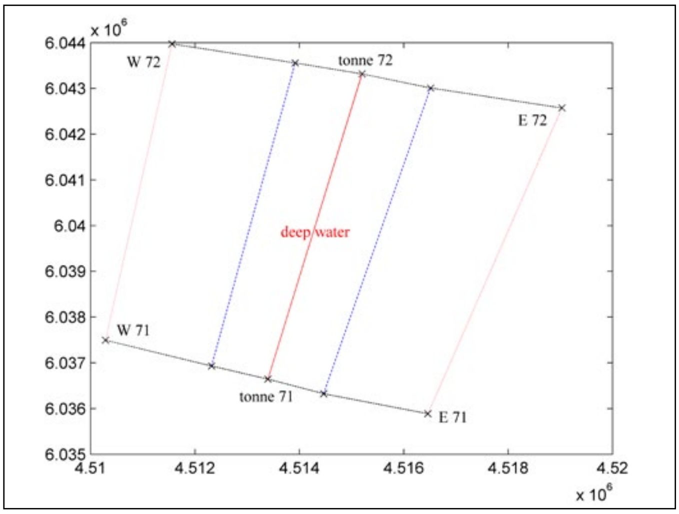


Figure 3: Core area of the KDT

### Traffic volume

The analysis of the resulting project database revealed that the number of vessels in the KDT slightly decreased over the years studied, i.e. from 03/2012 to 12/2014 (see *figure 4*). The period from 01/2009 to 02/2010 was excluded from the investigation of the traffic volume since – as mentioned earlier – the low AIS net coverage of the data source did not cover all ships and thus failed to identify all passages.

Estimated seasonal variations are only marginal and can be ignored. However, it has to be noted that every year, the traffic volumes show a dip at Christmas and return to the previous level with the turn of the year. The data of the years 2010–2014 document a total of 50,000 vessel movements, which contradicts reports on the matter [8 – 13] listing 65,000 to 85,000 vessel movements. Even if counting also those ships that moved in the complete sea area between the coastal lines but were not part of the traffic flow (ca. 2,500 p.a.) and including private ships (ca. 5,000 p.a.), the number of ship movements between the German and Danish coasts would amount to 57,500 at the most.

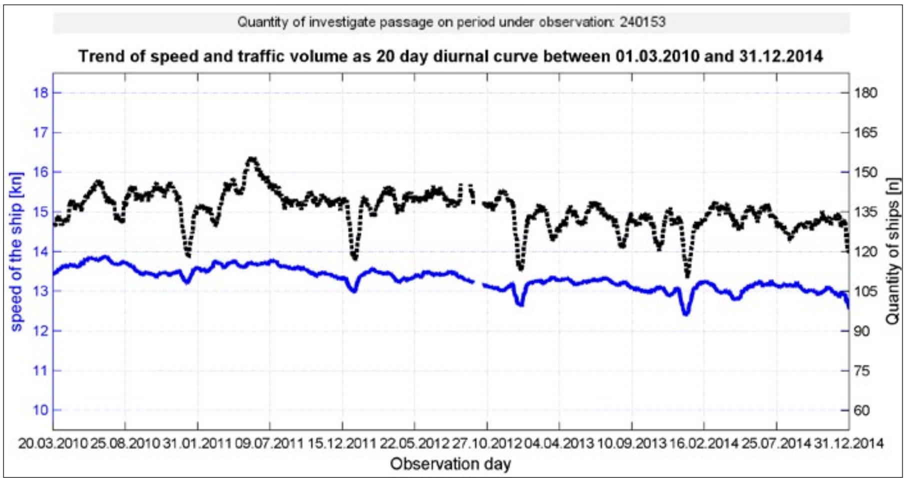


Figure 4: Traffic volume and traffic speed 03/2010 to 12/2014

### Traffic speed

During the observation period from 03/2010 to 12/2014, the average ship speed of the traffic flow was analyzed for a period of 20 days (see *figure 4*). The annual average of vessel speed remains relatively constant at 12.5 to 13.5 kn (1 kn = 1 sm/h ≈ 1.852 km/h). The only significant reduction of speed can be observed precisely at Christmas. Throughout the six years investigated, a slight reduction of the average speed can be observed. Whereas in 2010 the average speed was 13.5 kn, the speed in 2014 was 13.1 kn. Thus, from 2010 to 2014, slow steaming for the area of the Kadet Trench can only be traced at a very low level.

For the evaluation of *figure 5*: The ship‘s bridge team usually opts for a speed between 5 and 15 kn. The ships reported to travel at speeds beyond 20 kn as well as below 4 kn are very few. 99.8 % of all ships travel at an average speed of 24 kn or less. Traffic speed beyond 25 kn was only chosen by class A ships (see *figure 6*).

### Ship sizes and width

The 50-days average value curve in *figure 7* shows the development of ship length and width, confirming the general trend of increasing ship sizes. As expected, the ships' length increases proportionally to the ships' width. In 2014, the average ship in the KDT measured around 150 m in length and 22.5 m in width (values measured at the ship's entrance or exit of the Eastern Baltic Sea). It is remarkable that the ship size is higher in summer than in winter. A possible explanation might be the fact that cruise ships, which are generally rather large, mainly navigate the Baltic Sea during the summer months, which is reflected in the average value.

### Ship class categories

All vessels of the traffic flow in the KDT were categorized according to class (see *figure 7*) in order to draw conclusions on the composition of the traffic flow and the ship types. Vessel classes were labeled A to D and defined in relation to the length, the draft and the vessel type [14]. Thus, ships classes serve as an indicator of the potential damage that a traffic participant may cause in case of an accident. The category, however, offers no immediate risk assessment since that directly dependents on the abilities of the nautical personnel as well as on the technical condition of the ship.

### Composition of the traffic flow

The ship classes were used to study the composition of the traffic flow according to week days (see *figure 8* first line). It was shown that ship classes B and C represent the main groups in the KDT, with the third largest group consisting of class A ships and the smallest group being class D ships. Considering the fact that ships of class D are longer than 200 m or tankers with a draft of more than 11 m, their share of 5 to 10 % is rather significant. For these reasons, vessels that are identified as tankers in the AIS are listed separately in *figure 8* (bottom row of graphs). It can be observed that their number during week days is hardly affected by fluctuations.

A comparison of north- and southbound tanker movements (*figure 8*) reveals that the number of tankers leaving the area is higher than the number of tankers entering it. This might be explained by the fact that tankers moving southwards are loaded and have to sail the KDT because of their increased draft. Tankers entering the Eastern Baltic Sea can use the Öresund as an alternative route and profit from the shorter travel distance when passing through the Skagerrak (sea route north of Denmark).

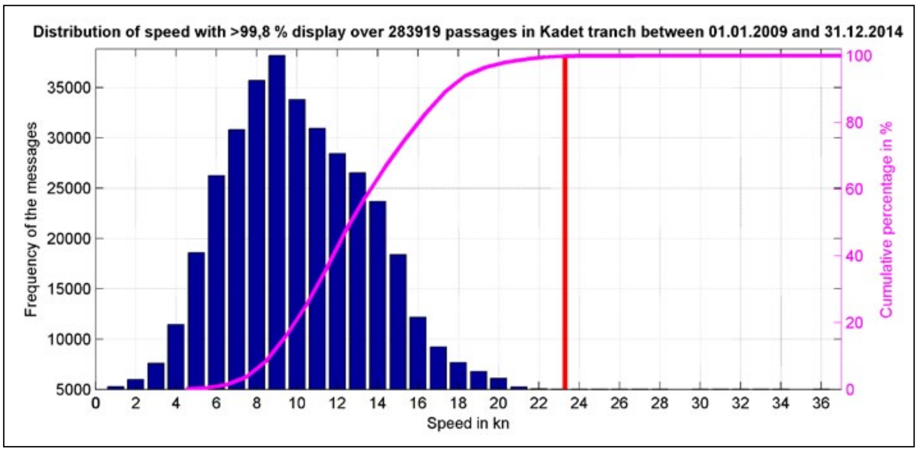


Figure 5: Speed in the KDT from 01/2009 to 12/2014

| length | draft | Group 1: Cargo ships & u.B. *(0 and 70's)* | Group 2: Passenger ship *(60's)* | Group 3: Tanker & special ships *(20,30,40,50,80,90's)* |
|---|---|---|---|---|
| < 50 m | < 11 m | A | B | B |
| < 50 m | > 11 m | A | B | B |
| 50 - 100 m | < 11 m | A | B | C |
| 50 - 100 m | > 11 m | B | C | C |
| 100 - 200 m | < 11 m | B | C | C |
| 100 - 200 m | > 11 m | C | C | D |
| longer than 200 m or more than 13 m draft | | D | D | D |

Figure 6: Ship class categories

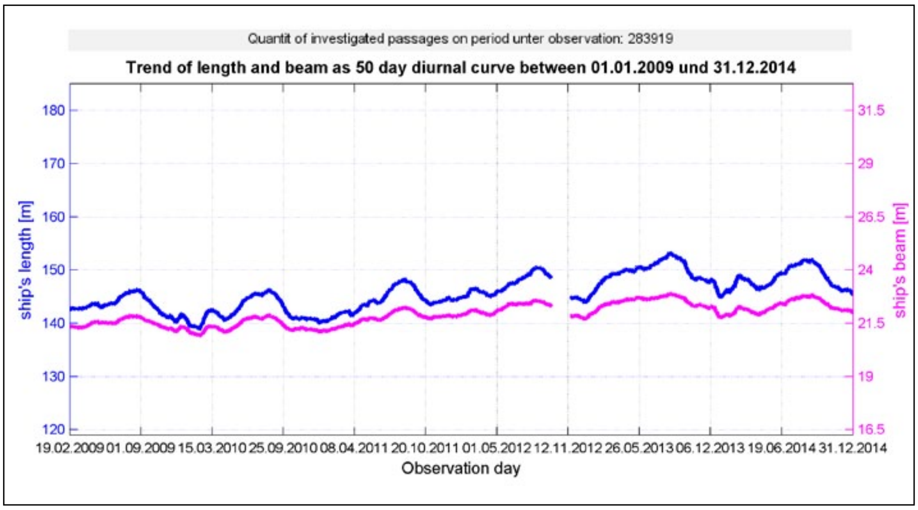


Figure 7: Ship size development since 2009

### Heatmap and congestion

Besides the analysis of single week days, we studied daytime congestion of the KDT (see *figure 9*, top), uncovering systematic differences. For this, we used the following

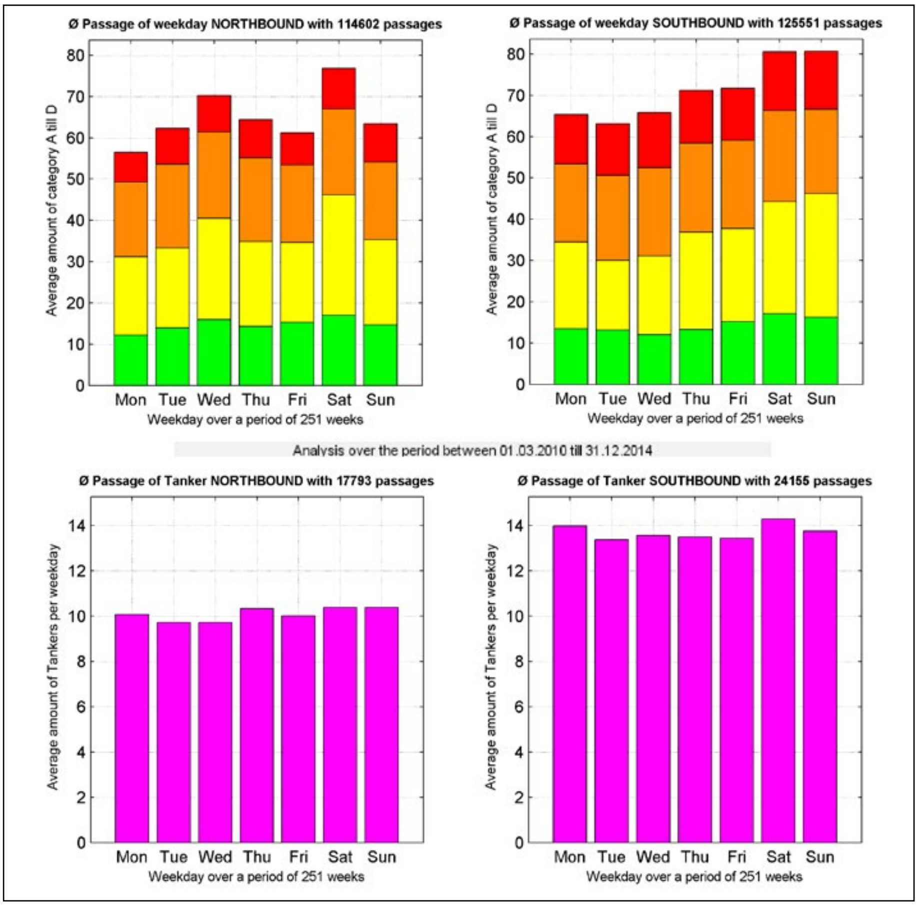


Figure 8: Composition of traffic flow and number of tankers

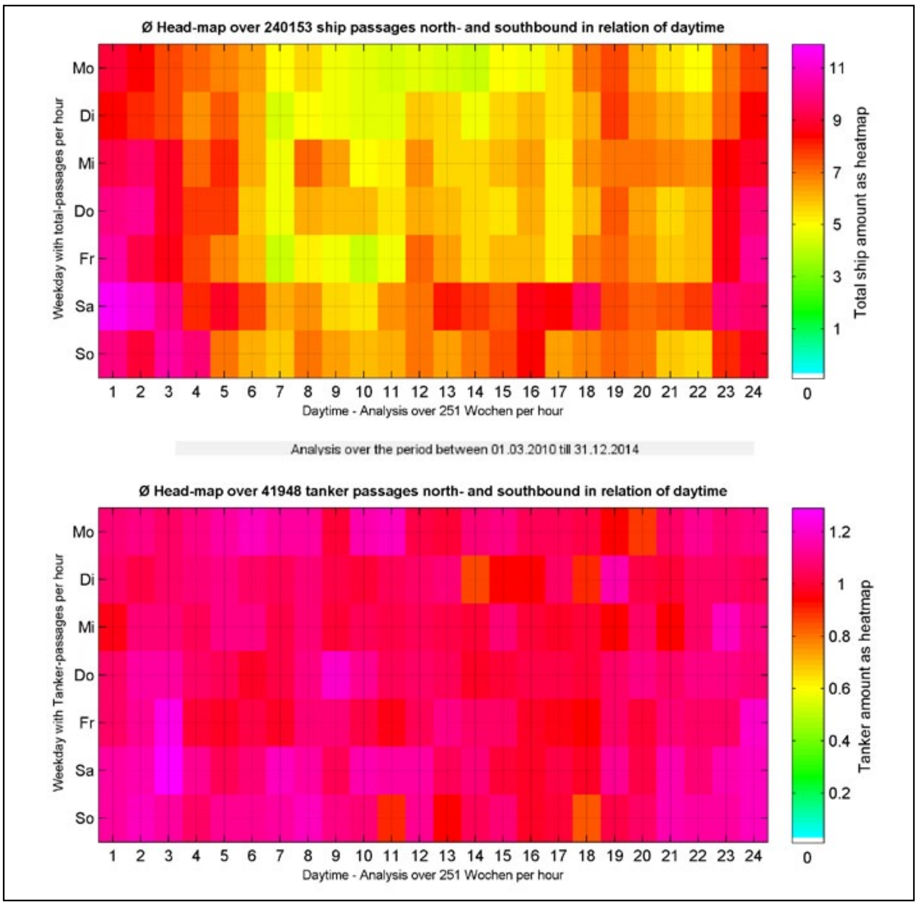


Figure 9: Congestion in the KDT, all ships and tankers

method: The daily and hourly numbers of southbound and northbound vessels were aggregated and then divided by the number of weeks under investigation in order to receive the average value. The data were visualized in a heatmap developed and adapted specially for this purpose. This map indicates an increased congestion in the early morning hours and during the late hours of the day. Thus, on week days between 6:00 and 22:00 o'clock, traffic flow is rather low. During the weekend, especially on Saturdays, traffic flow is significantly higher, especially around noon compared to the same time during the week.

In contrast, the heatmap of tanker passages (see *figure 9*, bottom) is quite homogeneous and does not indicate increased traffic on particular days or times. It can be observed that the average traffic flow is only marked by minor fluctuations, with an average of 1.1 to 1.2 vessel passages per hour.

## Overtaking in the KDT

Despite the challenges of the sea area due to the TSS, necessary significant course alterations of 80° and depth restrictions eastwards as well as westwards, overtaking maneuvers are regularly undertaken. During such a maneuver, a ship is identified as an overtaker if it was part of the traffic flow and entered the core area after and left it before the presumed predecessor. The resulting overtaking maneuvers of the different ship classes are represented in *figure 10*. The high number of overtaking maneuvers of class D ships is remarkable, especially in view of the fact that these ships are longer than 200 m or tankers with more than 11 m draft and a length of more than 100 m.

## Conclusion

The Kadet Trench (KDT) is one of the most frequented sea areas of the world. Due to the local characteristics described, special care is required in ship navigation. In particular, night hours with more than 10 ship movements per hour, ships of class D and the number of overtaking maneuvers increase the risk of accidents. The situation often leads to news coverage in the media, discussions in politics and analyses by researchers. It is to be hoped that no major accidents will occur in the KDT, especially with southbound tankers. ■

## LITERATURE

[1] Review of Maritime Transport, UNCTAD/RMT/2013, Sales no. E.14. II.D.5 United Nations, New York and Geneva, 2014

[2] Serry, A.: Dynamics of maritime transport in the Baltic Sea: regionalisation and multimodal integration. In: 6th International Conference on Maritime Transport, Barcelona, June 25-27, 2014

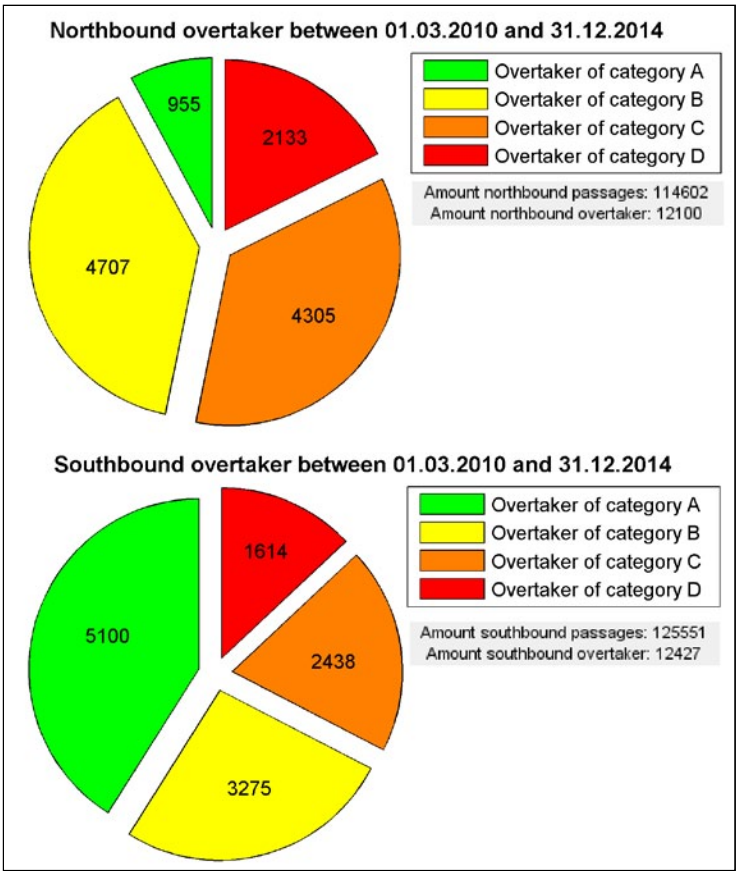


Figure 10: Passing maneuvers in the traffic flow

[3] Williams, D. W. (Hrsg.): Admiralty sailing directions: Baltic Pilot, Vol. 1. United Kingdom Hydrographic Office, London, 2004

[4] IMO: Resolution 620 A (15): Navigation Through the Entrances to the Baltic Sea: International Maritime Organisation, 1987

[5] International Marine Electronics Association (IMEA): NMEA 0183 V.4.1: Standard for Interfacing Marine Electronic Devices. Version of June 2012, Severna Park, MD, USA, 2013

[6] Hilgenfeld, C.; Hartmann, F.; Ahn, M.: AIS data as a basis for industry and science. HANSA International Maritime Journal 151 (2014), 8, p. 74–75

[7] Vojdani, N.; Ahn, M.; Hilgenfeld, C.: Aufbereitung von AIS-Daten der WSV-N für die Simulation von Seeverkehrssystemen. Fachgruppen-workshop. Arbeitsgemeinschaft Simulation. ASIM/GI, Stralsund, June 18, 2015

[8] Roß, Th.: Kadetrinne: Die Tankerfalle in der Ostsee, http://www.ndr.de/nachrichten/kadetrinne115.html

[9] Hamburger Abendblatt (HAB): Greenpeace in der Kadetrinne. Hamburger Abendblatt, 12.12.2002, www.abendblatt.de/wirtschaft/article106777236/ Greenpeace-in-der-Kadetrinne.html

[10] Hamburger Abendblatt (HAB): Experte fordert Lotsenpflicht in der Kadetrinne. Hamburger Abendblatt, 04.08.2010, www.abendblatt.de/region/norddeutschland/article107831761/Experte-fordert-Lotsenpflicht-in-der-Kadetrinne.html

[11] Gamillscheg, H.: Warten auf die Katastrophe. (Öresund): Der Schiffsverkehr in der Ostsee nimmt stetig zu. Vor allem die steigende Zahl der Öltanker macht den Experten Sorge. Ostseezeitung, 30.11.2012, S. 3

[12] Gamillscheg, H.: Die Ostsee wird für den Schiffsverkehr zum Nadelöhr. Hannoversche Allgemeine, Nov. 2, 2012, http://www.haz.de/Nachrichten/Der-Norden/Uebersicht/Die-Ostsee-wird-fuer-den-Schiffsverkehr-zum-Nadeloehr; accessed on Oct. 21, 2014

[13] Wikipedia: Kadetrinne, http://de.wikipedia.org/wiki/Kadetrinne; accesssed on July 1, 2015

[14] Ulusçu, Ö. S.; Altıok, T.; Or, İ.; Özbaş, B.: Risk Analysis of the Vessel Traffic in the Strait of Istanbul. Risk Analysis 29 (2009), 10, p. 1454–1472

**Nina Vojdani**, Prof. Dr.-Ing.
Head of the Chair of Production Organization and Logistics [LPL], Faculty of Mechanical Engineering and Marine Technology, University of Rostock (DE)
**vojdani@uni-rostock.de**

**Manfred Ahn**, Prof. Dr.-Ing.
Professor for Traffic Planning and Urban Planning, University of Applied Sciences Wismar (DE); Steinbeis-Transfer-Institute Laws, Economics and Operations
**manfred.ahn@hs-wismar.de**

**Frank Hartmann**, Dipl.-Ing.
Department of Maritime Studies,at University of Applied Sciences Wismar (DE)
**frank.hartmann@hs-wismar.de**

**Carsten Hilgenfeld**, Dipl.-Ing. (FH), M.Sc.
Department of Maritime Studies, University of Applied Sciences Wismar (DE)
**carsten.hilgenfeld@hs-wismar.de**

# Solutions for a global challenge – Made in Germany

## German Partnership for Sustainable Mobility as a solutions network

Germany is a world leader in sustainable, innovative and efficient mobility solutions. By gathering German knowledge and expertise, the GPSM makes a valuable contribution to the international dialogue on smart transportation and to sustainable development worldwide.

Over the last decade, the total number of private cars has increased by more than 25% to 850 million worldwide. Transport consumes half of the global oil production. As 90% of the transport sector is dependent on oil, most wheels on the planet would not roll without it. We expect the emission of $CO_2e$ in the transport sector to double to 1,000,000,000,000 tonnes from 2000 to 2050. At the same time, many people across the globe still do not have access to adequate means of transport: One billion people lack all-weather roads in their local area, where the nearest drivable street is over half an hour away by foot. Other cities suffer from major congestion and air pollution.

The challenge is obvious: providing adequate means of transport while minimizing environmental impact and maintaining a high quality of life. The German Partnership for Sustainable Mobility (GPSM) serves as a guide to sustainable mobility and green logistics solutions from Germany. As a platform for exchanging knowledge, expertise and experience, the GPSM supports the transformation towards sustainability in developing and emerging countries. It serves as a network of information from academia, businesses, civil society and associations.

The friends of the GPSM already provides their services in developing and emerging countries, others develop ideas and concepts. Some of our friends' expertise is outlined in the following.

**Contact:** Michel Arnd
michel.arnd@german-sustainable-mobility.de

German Partnership for Sustainable Mobility
*Sustainable Mobility – Made in Germany*

More about us:
www.german-sustainable-mobility.de

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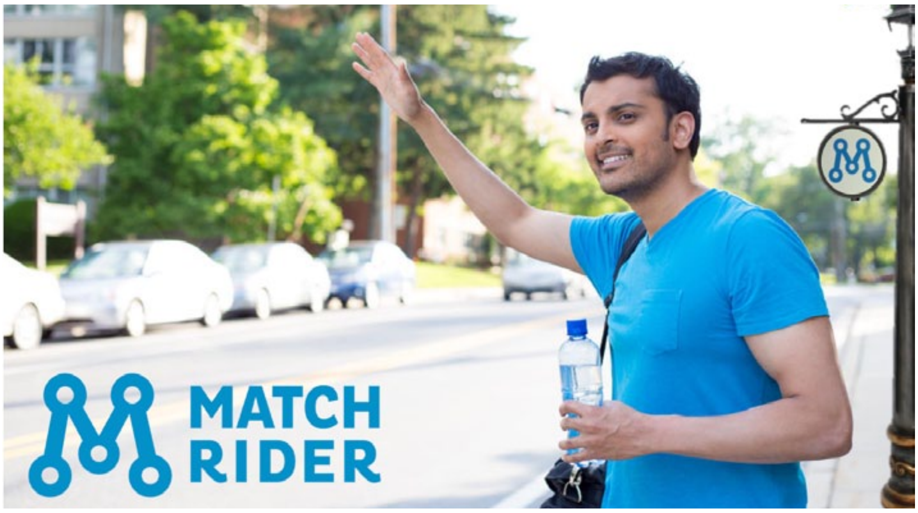
**Ridesharing in developing and emerging countries**

Carpooling or ridesharing is nothing new in developing countries. Limited access to private automobiles and the generally low income level have helped drive the growth of these ways to travel. Many countries also encourage sharing rides by allowing only cars occupied by more than one individual to enter their mega-cities, a practice that has for instance spurred the growth of the so-called "Jockey" in Jakarta, Indonesia.

MATCH RIDER




Countries that have already established positive cultural norms around sharing rides provide great landscapes for app-based or "dynamic" ridesharing[1] (not ride-selling[2]) innovations. Here are three areas where new technologies can increase the adoption of carpooling:

**Trust** – Increased safety through verified user profiles based on photos, user ratings and detailed contact information. Trust is the currency of successful peer-to-peer marketplaces, and new technologies make identity verification reliable and easy. User preferences allow drivers and passengers to automatically filter rides, for example, by gender, smoking preference, or place of work.

**Payment** – Cashless payment systems eliminate the need for negotiating prices and make the transaction transparent for both passengers and drivers. (In some developing countries, cashless mobile payment is already common practice). Users will worry less about getting ripped off or not receiving their payment.

**Increasing access** – Advanced algorithms are designed to maximize the potential for a carpool match. Individuals in more suburban or rural areas have greater transparency about who from the neighboring village is commuting at a similar time.

There are numerous additional advantages that go above and beyond this summary. For more information about the benefits of dynamic carpooling for emerging and developing countries, I would be pleased to get in touch with you.

*Katina Schneider,*
*Match Rider, Heidelberg (DE),*
*Katina@matchrider.de*
*or on twitter @__katina__*
*www.matchrider.de*

1 Definition of ridesharing: Synonym for carpooling - forming of a carpool with a private vehicle for a specific route. The driver determines when and where the trip will go. The ride takes place even if no person joins. Generally the costs of the ride are shared. (Source: Zukunft Mobilitaet)

2 Definition of ride-selling: Offering rides on a private vehicle. The passenger determines whether the ride happens and the destination of the ride. The ride would not take place without a request from a third party. The price of the ride is generally higher than the cost of the trip. (Source: Zukunft Mobilitaet)

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Doppelmayr®

### Public transport in difficult topographies and neighborhoods with no access

Metrocables/urban ropeway systems are excellent means to help cities master their transportation and mobility challenges, from crossing rivers, climbing mountains, bypassing and reducing traffic congestion.

One may be familiar with the use of ropeways on mountains. This is where much of modern ropeway technology has been deployed and developed over the past hundred years. Today, that same technology is being brought down from the mountain and incorporated into cities as an integral part of urban public transportation networks on nearly every continent.

Some cities have quickly adopted ropeway systems as a cost-effective, quickly implemented, low-footprint, and safe mode of urban transportation. The ropeway is a means of public transport that can be optimally linked to existing transport systems. Particularly in cases where there are barriers to overcome (such as traffic congestion, buildings, waterways, roads or railway lines), ropeways may cost less than ground-based transport systems, which require expensive bridges or tunnels to circumvent obstacles.

#### *The Caracas Metrocables, San Agustín in Venezuela*

Due to population growth and an absence of suitable town planning, before the Metrocables system was built, large parts of the 70-hectare district were only reachable via winding steps and narrow footpaths. In order to integrate San Agustín with the rest of the city, new roads were designed. These plans, however, were never realized because they would have required the demolition of 20-30 % of all houses in the district. Instead, a ropeway system was designed to work around that challenge. Today, this system provides the 40,000 inhabitants of San Agustín with a fast and convenient link to both the road network and the subway system located at the base of the hill.

The Caracas Metrocables have a direct positive impact on quality of life:

- Commuters save money since they can transfer directly to the metro line instead of paying two or more fares. Total travel times have decreased by up to an hour.
- Children can access schools safely and in much less time.
- Stations were built as community centers, integrating a concert hall, educational facilities, shops, and a sports hall.
- Riders add “eyes on the streets”, thereby helping to reduce crime in the area.

The Caracas Metrocables is a success. This is why Metro de Caracas is planning another nine systems across the city. At the same time, Metrocables acts as a showcase for other cities in Latin America as well as the rest of the developing world.

*Katharina Anna Bernard,*
*Doppelmayr Cable Car, Wolfurt (AT)*
*katharina.bernard@doppelmayr.com*
*www.doppelmayr.com*

ally

**Improving public transport by smart technology in Dar es Salaam**

The era of mega-cities and the urbanization trend, with roughly 6 billion people expected to live in cities by 2050, come with certain challenges. To our belief, they come with tremendous opportunities as well, opportunities driven by technology and by the right use of connectivity and data.

The Smart Cities approach rests upon the belief that the future can be shaped through the deep understanding of cities. Mobility is a crucial element for the positive evolution of urban life and is a core element of cities' life. Therefore, without a strong, functional mobility system, cities – no matter how 'smart' they are – will collapse.

And technology plays a big role in this: Thanks to its advances and to the programs and methods developed, we can not only map a full city and its transport system, but also analyze commuting behavior, transport patterns and perks, and improve them. We can make a city smarter and ensure its functionality and survival.

Dar es Salaam in Tanzania is an example of what we do. As a city stuck in traffic gridlock, with commutes taking an average of three hours, the city has the choice of either becoming a car-dominated transport city – which will lead to an extreme amount of time and human energy wasted in commuting – or a demand-driven public transport city, that can save time and make commuting more enjoyable.

We at ally can support the city implement the latter choice.

Three major steps are needed:

1. To understand a city and its public transportation system, the first step is to map its major roads. In Dar es Salaam, this was done in a joint effort with several organizations including the World Bank, Humanitarian OpenStreetMap Team (HOT), international Red Cross chapters and ally.
2. Once the basic city grid is mapped, what follows is the tracking of the transportation system. In Dar es Salaam, the dominating form of public transport is the Daladala system, and their routes were tracked with GPS devices, post-processed, and converted to the GTFS standard, which was later incorporated in the ally app.
3. A prerequisite for data-driven decisions is having a sufficient pool of data producers: the users. A comprehensive user base will be able to produce meaningful data as a basis for smart solutions. In Berlin, for example, we can analyze the demand of public transport to and from Tegel Airport and compare it with the currently available public transport options. Based on the insights gained, the relevant authorities can make focused decisions for demand-driven public transport.

Technology and data can have a major and above-all positive impact on the cities' urban evolution and mobility. Such visionary thinking is taking shape in ideas such as Autonomous Driving and Dynamic On-Demand interactive systems, that will connect people with Public Transportation on the road to achieve real-time mobility needs fulfilment and thus debunking the old system based on historical outdated assumptions.

Because this is the era of digitalization: When intelligent data provides immediate feedback that can be used every day by governments and citizens to tackle transport and mobility challenges, we at ally join the revolution and provide tools to make changes possible.

*Ulrich Strötz, uli@allyapp.com, @ustroetz*
*Isabel Flores, isabel@allyapp.com, @ally_helena*
*Erica Couto, erica@allyapp.com, @mscoutoe*
*ally, Berlin (DE)*
*www.allyapp.com*

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teamred MOBILITÄTS AKADEMIE

**The team red Akademie gGmbH**

The team red Akademie, founded in December 2014, is recognized as nonprofit organization. As part of the team red group, it offers an open and transparent platform for communication and exchange in the context of the transformation to a post-fossil fuel society. The focus is on mobility and transport, but all industry-related fields, from energy to behavioral psychology, are included in the discussion.

*Our objective and proposal*

The idea of the team red Akademie is to use the consulting and implementation expertise that team red has gathered in the over 12 years of its commitment to future mobility. It aims to provide this know-how to municipalities, companies, associations, NGOs and other institutions for their daily work. For this purpose, we organize workshops, seminars, meetings, conferences, trainings and educational trips.

The academy provides the framework for a high-quality network of stakeholders in the mobility market. It is an orientation platform, a booster for startups, a discussion forum and a place for publicizing new ideas, all these with the aim of developing a low-$CO_2$ and "post-fossil" mobility system.

Communication activities such as small- and large-scale events, virtual meetings using online conference technology, and not least the "Bürgerbüro Elektromobilität" (Citizens Office for Electro-mobility) in Berlin are open to businesses and citizens alike.

The team red Akademie supports expert dialogue and knowledge exchange on an international level by organizing educational journeys to the scenes of innovative mobility solutions. Details including the program of academy events can be found on the following websites:

- www.mobilitaets-akademie.de
- www.e-cademy.net
- www.learning-journey.com

*René Waßmer,*
*team red Akademie gGmbH,*
*Berlin (DE)*
*rene.wassmer@team-red.net*

# Meta for the win?

## Success factors for meta-search engines in online travel distribution

Meta-search engine, business model, online travel distribution, coopetition, intermediation

The importance of digital distribution in the travel industry is strongly increasing. Virtually any travel supplier or hotel is able to market its services directly on the Internet. Web platforms, like online travel agencies (OTAs), are taking over trading functions and facilitate sourcing information for the customer. In addition to trading platforms, meta-search engines like Kayak, Qixxit, momondo and Rome2Rio have evolved and are making the market more transparent. But what is so special about 'Meta'? Can it work in the long run? Is Meta the most important, if not the only successful kind of business model in online travel distribution?

Authors: Alexander Eisenkopf, Christopher A. Haas

Looking at the international travel market, the number of web platforms for searching and booking travel-related services is huge. Meta-search engines aggregate offerings of trading platforms and travel suppliers alike, and provide this information to the user. The idea of this paper is to discuss success factors of meta-search engines. It is based on case studies, supported by interviews with decision makers of successful meta-search engines and industry experts from associations from the travel industry. The theoretical background is provided by the theories of coopetition and intermediaries.

The paper is structured as follows: Following a short description of the value chain, we explain the functions and the role of meta-search engines in online travel distribution. Based on the idea of meta-search engines as an intermediary we then discuss the development of business models and market structure in the online travel market.

### Distribution value chain/net

The online travel market mainly provides three points of contact for the consumer with the travel product: online travel agencies (OTA), meta-search engines and suppliers' websites for direct distribution.

*Figure 1* illustrates that different ways of distribution involve different numbers of players and therefore may use different pricing methods. It seems obvious that direct distribution, as long as transactional costs and customer coverage are equal, is the cheapest way of distribution for suppliers, since they do not have to share the achievable margin with any intermediaries. The fact that Lufthansa introduced a special fee for GDS bookings with the aim to foster their direct channel has just confirmed this.

### What does a meta-search engine do?

In general, meta-search engines fulfil the purpose of aggregating information that is available on the Internet and has already been indexed by search engines. The main advantage of a meta-search engine is the combination of search results of other search engines in a single user interface (Lawrence and Giles, 2006). In the area of travel services, the meta-search engine aggregates inventory and rates from online sources and provides these to a user via a single query. Compared to an OTA or a supplier portal, a significant difference is that a meta-search engine does not process booking transactions and fulfilment, but provides an overview of different rates for the same product. A meta-search engine redirects the users to the suppliers' websites where the users may subsequently make a booking (Christodoulidou et al., 2010, Schaal, 2015). This implies that the users do not conclude a contract with the meta-search engine since the latter is not a merchant. They only enter in a contractual relation with the entity owning the booking engine that they are redirected to, the meta-search engine´s advertiser.

*Figure 2* shows the inventory flow and how a meta-search engine aggregates information from OTAs, GDSs and even suppliers' booking capabilities on a single platform.

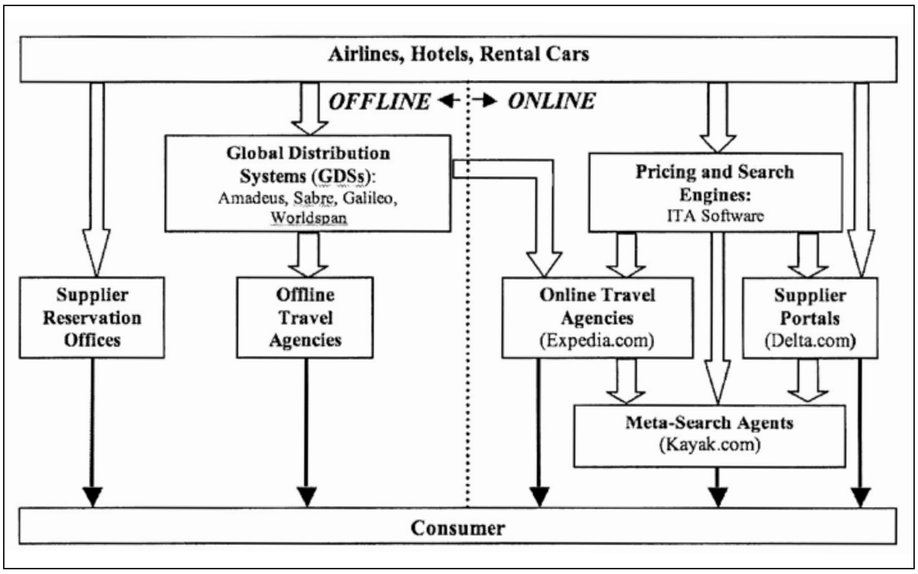



Figure 1: Travel distribution & information value chain    Source: Granados et al., 2008

***Why do travelers use meta-search engines?***
Meta-search engines find themselves to be more and more frequently used by travelers. One possible explanation is that the average online travel buyer has a higher demand for information before taking a decision. In total, an online booker makes an average of 32.5 visits to more than 10 websites over a period of 73 days before the booking is completed (May 2013). In 2013, 36 % of travelers in the US used meta-search engines for travel shopping. At the same time, 42 % of travelers in Germany used a meta-search engine for travel shopping (Nielsen, 2014).

In the value chain of online travel distribution, the meta-search engines cover the steps ‘inform’, ‘compare’ and ‘validate’ as shown in *figure 3*. This means, that the meta-search engines offer the users information about available products, enabling them to compare the different offers and finally to validate them to find out whether their choice is the ideal offer according to their travel needs. The booking process, however, is still owned by the OTA or the direct supplier.

## Aggregator & integrator

One of the strengths of meta-search engines is their ability to aggregate and integrate information and thus provide market transparency for the user on the one hand, and open up additional access to consumers for the advertiser on the other hand. It may be said that the core capability that a meta-search engine needs to create value, is the aggregation of inventory and content. This is the enabler for every further service that can be provided by a meta-search engine, be it personalization or even establishing contact with a travel companion. Thus, the meta-search engine highly depends on its suppliers.

***The role of intermediary***
For the users, the information provided by a meta-search engine is highly valuable as it helps them to find the ideal travel product matching their individual use cases and travel requirements. Trustworthiness and the provision of a comprehensive overview of the market are important. Users might move to a different platform once they become aware that the platform they are currently using may not deliver a comprehensive picture of the market. Thus, comprehensive information may be assumed to be the justification of existence of any meta-search engine in the online travel market.

To maintain a high level of comprehensiveness, up-to-date and high-quality data interfaces are necessary. The ability to source all available information from the advertising partners of a meta-search engine is therefore crucial when it comes to offering a product that is of a certain value for the user. Hence, standardized automated data interfaces, like the one already introduced for air travel by IATA’s NDC, might be the future. This also makes it possible for the user to directly connect with suppliers more easily via a standardized interface, and for the meta-search engine to integrate a virtually limitless number of suppliers using a single API format.

Meta-search engines are seeking direct commercial relationships with travel suppliers to strengthen their position in the value net. However, there might be a certain risk in this strategy. Engaging in a direct business relationship with suppliers, whether they are hotels or airlines, shifts the risk of CPC advertising to the direct supplier. Performing online travel distribution via OTAs, the risk of CPC advertising is cushioned by the OTAs since suppliers pay a commission per sale to the OTA. The OTA is the intermediary that advertises its inventory on its own behalf on the meta-search engines. In this context, the OTAs benefit from economies of scale and an extensive portfolio, which mitigate a potential loss in a small number of items. However, in a direct relationship between supplier and meta-search engine, this risk – but also the corresponding advantages – shift directly to the supplier. The future development will show whether suppliers will accept this business model in the long run or not. A further risk of connecting directly with suppliers, e.g. an airline, may be a loss of neutrality and comprehensiveness in the search results of a meta-search engine. This applies in particular to any case where a supplier connects directly to more than one meta-search engine but provides different rates to each of them. In this case, any meta-search engine would need to integrate the results of other meta-search engines to remain a provider of true market transparency.

***Merger of business models***
Looking back to the year 2000 and the subsequent rise of OTAs, those were in a similar position as meta-search engines are today. Back then, OTAs fulfilled the role of market transparency providers by aggregating travel products on a website and thus allowing travelers to compare. When more and more OTAs entered the market, meta-search engines took over this role and restored market transparency, in this case not by comparing the individual suppliers’ offers, but the offerings of the OTAs. OTAs and meta-search engines emerged from an internet-based process of re-intermediation. Through the strong growth and the emergence of a larger number of OTAs over the years, market transparency was lost to a certain extent because too many players offered too many different prices for travel products. To restore market transparency, a new intermediary appeared in the form of meta-search engines. A certain risk for meta-search engines therefore lies in the fact that they might evolve to the status of OTAs once they have too many direct commercial relationships with suppliers. If two meta-search engines collaborate with the

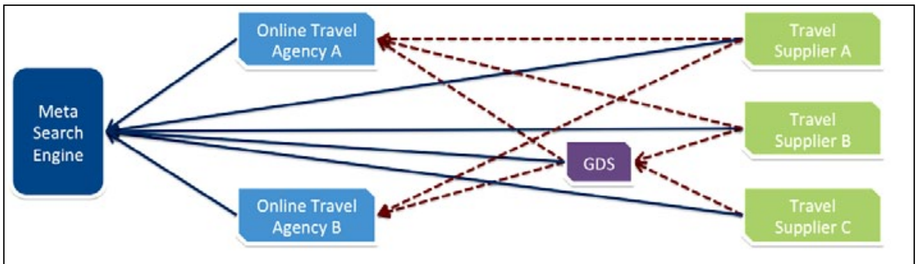



Figure 2: Meta-search engines in online travel distribution Source: Eisenkopf et al., 2014

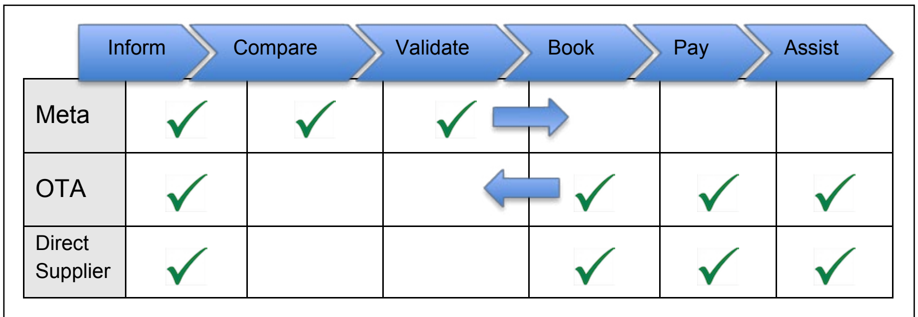



Figure 3: Suppliers, OTA and meta-search engines in the online distribution value chain

same supplier, and both show a direct offer of the supplier, why should this supplier provide the same rate to both metas? In such a case, comprehensive information will get lost and market transparency cannot be provided anymore.

In addition, the meta-search engines' business model does currently not include the role of actual fulfilment. But as the interviews we conducted with industry experts show, the expansion to further areas of the value net, including booking and fulfilment capabilities, is an option if meta-search engines want to further improve the experience for their users and the service/product for their suppliers.

Following this trend, the evolution of the market may lead to a merger of the business models currently used by the OTAs and the meta-search engines, as shown in *figure 3*, so that we cannot distinguish both models anymore. In this case, OTAs would start to include competitors' prices to enable their users to compare offers and validate decisions. At the same time, meta-search engines may move to a CPA model. Under a CPA model (Cost-Per-Acquisition), the advertiser is only charged once a booking is completed. Consequently it is easily scalable, reduces the risk for advertisers and opens the door for meta-search engines to integrate booking and fulfilment into their service range.

### *Market consolidation*

A further topic is the conceivable future consolidation of the market. Today's meta-search engines in online travel distribution often belong to an OTA or even to a travel supplier.

In theory, consolidation leading to a duopoly market may clear the path for a new approach of disintermediation and re-intermediation. Looking at the current process of market consolidation, we may assume only two large OTA-focused companies will still be in the market in a few years. However, the market for online travel distribution is still highly vulnerable and constitutes a fast changing environment. GDSs like Amadeus may suffer from disintermediation once meta-search engines and OTAs unfold their full potential in setting up direct commercial relationships with suppliers, bypassing the GDSs' services.

However, meta-search engines entered the value chain of online travel distribution to provide market transparency and easy access to a comprehensive overview of the market. This opportunity arose in particular when the increasing number of OTAs made it difficult for the user to compare travel opportunities and prices. Meta-search engines recognized a certain demand for market transparency by the potential users and created websites that would offer the possibility to compare offers by providing the best possible information in an easy-to-use way. Looking at OTAs, which initially entered the market to fulfil a similar role – provide information and market transparency – the re-intermediation through the establishment of meta-search engines and their increasing number may lead to a repetition of the re-intermediation process of the late 1990s and enable further business models to evolve. This parallelism is underlined by the fact that meta-search engines have started to enter the direct distribution channels by enabling travel providers to bypass OTAs and provide rates and availability directly to a meta-search engine. In e-business, this step of disintermediation is not surprising, but having suppliers providing rates and availability directly to meta-search engines may give rise to the need for an intermediary that compares the direct offers of the metas and thus restores market transparency. This potential new player, let's call it a 'Square-Meta', may collect and compare the meta-search engines' (direct) inventory. In case that meta-search engines keep their strategy of focusing on one specific product type, such as transport, the Square-Meta may even take the role of an integrator offering on-demand bundles, thus combining the most suitable results of a transport meta-search engine with the optimally matching results from an accommodation meta-search engine or even sourced from a meta-search engine that offers both verticals. Doing so may enable each player to concentrate on their core capabilities and deliver an even better product.

## BACKGROUND INFORMATION

### Meta-search business model

The most popular business model for meta-search engines is Cost-Per-Click (CPC). An advertiser (supplier or OTA) placing their offers on a meta-search engine pays a specific amount of money each time a user clicks on the related advertisement. By providing aggregated information to a user, the click is perceived as a 'qualified lead'. This means, the referral has a certain value, because the interest of the user is rated high, as is the likelihood that the user might make a booking. A meta-search engine does not charge the users for the service, but only the partners that advertise their inventory in order to reach the broad audience provided by the meta-search engine.

### Open future

The question 'Meta for the win?' can only be answered with 'it depends'. It clearly depends on how meta-search engines and OTAs decide to evolve their business model and how the business models of their suppliers will develop. The only thing that is clear is that the current model is not here to stay, because pressure for change in the industry is strong. The whole industry is in a constant state of flux, and further intermediaries are likely to enter the market. ■

## SOURCES


Christodoulidou, N., Conolly, D. J. & Brewer, P. 2010. An examination of the transactional relationship between online travel agencies, travel meta sites, and suppliers. International Journal of Contemporary Hospitality Management, 22, 1048-1062.

Eisenkopf, A., Geis, I., Haas, C. A., Enkel, E., Kenning, P., Jochum, G., Schulz, W. H. & Grotemeier, C. 2014. To Develop and Validate a European Passenger Transport Information and Booking System Across Transport Modes.

Granados, N. F., Kauffman, R. J. & King, B. 2008. How Has Electronic Travel Distribution Been Transformed? A Test of the Theory of Newly Vulnerable Markets. Journal of Management Information Systems, 25, 73-95.

Lawrence, S. R. & Giles, C. L. 2006. Meta search engine. Google Patents.

May, K. 2013. Deep dive into travel research activity by online and offline bookers. tnooz [Online]. Available from: http://www.tnooz.com/article/travel-research-google-online-acitvity [Accessed Jan. 6 2015].

Mielsen, S. 2014. Expedia's trivago acquisition raises advertising revenue growth [Online]. marketrealist.com. Available: http://marketrealist.com/2014/04/expedia/ [Accessed Mar. 7 2015].

Schaal, D. 2015. The State of Travel Metasearch in 2015. Skift Trend Report.



**Alexander Eisenkopf**, Prof. Dr.
ZEPPELIN-Lehrstuhl für Wirtschafts- und Verkehrspolitik,
Friedrichshafen (DE)
alexander.eisenkopf@zu.de



**Christopher Haas**, M.A
Düsseldorf (DE)
christopher.a.haas@gmail.com


Photo: Vogel

# The environmental impact of electric vehicles in China

## A climate-friendly solution or an exacerbation of the problem?

Climate impact, environmental policy, market incentives, lifecycle assessment

Monetary purchasing subsidies, super credits, tax exemptions and local incentives for industry and consumers: China is sparing no efforts in its drive towards market expansion for e-mobility. The motives of China's industrial policy are straightforward, yet environmental protection as a driver is not equally unambiguous. Prevalent coal-fired electricity production is sparking doubts whether an electrification of motorized individual mobility will have a positive impact on the climate. A Sino-German cooperation project[1] addresses these issues by assessing the environmental impact of electric vehicles in China.

Authors: Frederik Strompen, Christian Hochfeld, Ye Wu

As an important economic driver in China, the automotive sector is a significant provider of employment and shapes technological innovation. It has significantly contributed to China's unprecedented economic growth over the past decades. Conversely, daunting climate and environmental concerns have cast a shadow on this development. Air pollution, noise, accidents, congestion – the list of very tangible, negative external effects of transport is long. Less perceptible, but significant effects are the greenhouse gas emissions released by countless internal combustion engines burning fossil fuels. The associated negative social, environmental and climatic impacts create a real dilemma: Implementing environmental policies in the transport sector that are conducive to trade, personal mobility and economic development while preventing negative external effects such as climate change, is a challenging yet inescapable mission for Chinese policy makers. With its 12th five-year plan (2011–2015), the Chinese Government identified the promotion of electric vehicles (EV) as a key to addressing this challenge.

Catching up with other industrialized nations through a technological leapfrog in automotive engineering while reducing the dependency on oil imports, mitigating tailpipe and greenhouse gas emissions would be an economic and environmental win-win situation for China. Yet, the EV market has not met the Government's expectations in terms of overall sales numbers – as is the case in many other countries in the industrialized world, including Germany. Just short of 110,000 EVs were registered in China by the end of 2014. The sales target of 500,000 vehicles by the end of 2015 is barely reachable. The trend, however, is promising. With 83,900 vehicles sold in 2014 alone, the market really started to advance last year. In July 2015 alone, Chinese vehicle manufacturers produced a total of 20,000 EVs – 3.5 times as many than in the same month of the previous year. In contrast to the conventional vehicle market that is dominated by foreign manufacturers, domestic producers like BYD and the BAIC currently dominate the national EV market. This dominance is partly caused by the design of the promotional regulatory framework, which most strongly benefits EVs produced in China.

To what extent EVs alleviate the environmentally harmful effects of motorized transport depends on a number of influencing factors. When driven (in purely electric mode), EVs produce neither air pollutants nor greenhouse gases at the tailpipe. The environmental impact of EVs really depends on upstream emissions such as the emissions caused by electric power generation as well as the vehicle manufacturing and recycling process. Whether the electricity is generated from renewable energy or from fossil fuels is a key question in this regard. Additional factors play an important role. These include: the number of EVs in the market, vehicle kilometers travelled (VKT) and their real-world power consumption, the resource efficiency of the production/recycling process and the type of vehicles they replace.

## Electric vehicle policy in China

The Chinese State Council is currently aiming for a target of five million EVs registered by 2020, with one million EVs to be produced by Chinese manufacturers. A number of fiscal and non-monetary policies have been put in place to reach this goal.

Building on the experiences from earlier programs in China, monetary incentives have been put in place: The benefits are dependent on the electric range of the vehicle (see table 1) and will gradually decline from 2016 to 2020.

To comply with the recently published fuel economy standards, the automotive industry has to lower the average corporate fleet consumption to 5.0 liters per 100 kilometers by 2020. To encourage EV sales, so-called super credits are awarded. Each (plug-in) EV sold is credited with a multiplier as a zero-emission vehicle (the multiplier gradually decreases from the factor 5 in 2016 to the factor 2 in 2020). Financial subsidies for the development of charging infrastructure are channeled from the national government to the municipalities in proportion to the number of locally registered EVs. Also, obligatory procurement guidelines to increase the share of EVs in public fleets have been released.

National efforts are complemented through promotional policies on a municipal level. A total of 88 nationally approved pilot cities are currently implementing a wide range of local EV policies that aim to curb local protectionism, expand charging infrastructure and increase the share of EVs in municipal and private fleets. Cities compete for the status as a pilot city and the associated budget allocation. Available national sales subsidies can be doubled by municipalities. To encourage EV ownership beyond that, the Beijing municipality has introduced a special quota in the number plate lottery exclusively for EVs. This leaves the consumer with an 88 % chance of receiving a number plate for an EV and a 0.5 % chance for a conventional combustion engine. Moreover, the city of Shenzhen includes bus and taxi operators in the emission trading scheme to encourage the procurement of "zero-emission vehicles" while Shanghai excludes EVs from its vehicle auction (equaling a monetary value of 80,000 RMB). Still, a crucial question remains unanswered: Are these significant promotion policies justified from an environmental standpoint?

## Lifecycle assessment (LCA) of electric vehicles

The best (LCA) tool and dataset that is available in China (see *figure 1*) was applied to look into this question. The model com-

| | Subsidy criteria | Phase III: 2016–2020 (EUR) | | | Subsidy criteria | Phase II: 2013–2015 (EUR) | | |
|---|---|---|---|---|---|---|---|---|
| Vehicle type: | 2016 – 2020 Range (km)/Length (m) | 2019–2020 (-40 %) | 2017–2018 (-20 %) | 2016 (Baseline) | 2013–2015 Range (km)/Length (m) | 2015 (-10 %) | 2014 (-5 %) | 2013 (Baseline) |
| Battery electric passenger vehicles | 100–150 km | 15,000 | 20,000 | 25,000 | 80–150 km | 31,500 | 33,250 | 35,000 |
| | 150–250 km | 27,000 | 36,000 | 45,000 | 150–250 km | 45,000 | 47,500 | 50,000 |
| | 250 km and more | 33,000 | 44,000 | 55,000 | 250 km and more | 54,000 | 57,000 | 60,000 |
| Plug-in hybrid electric passenger vehicles | 50 km and more | 18,000 | 24,000 | 30,000 | 50 km and more | 31,500 | 33,250 | 35,000 |
| Battery electric busses | Subsidy based on:<br>– energy efficiency<br>– weight<br>– length | Up to:<br>360,000 | Up to:<br>480,000 | Up to:<br>600,000 | 6–8 m | 270,000 | 285,000 | 300,000 |
| | | | | | 8–10 m | 360,000 | 380,000 | 400,000 |
| | | | | | 10 m and longer | 450,000 | 475,000 | 500,000 |
| Plug-in hybrid electric busses | Subsidy based on:<br>– energy efficiency<br>– weight<br>– length | Up to:<br>180,000 | Up to:<br>240,000 | Up to:<br>300,000 | 10 m and longer | 225,000 | 237,500 | 250,000 |

Table 1: National EV subsidies in China from 2013–2020

Source: Ministry of Science and Technology

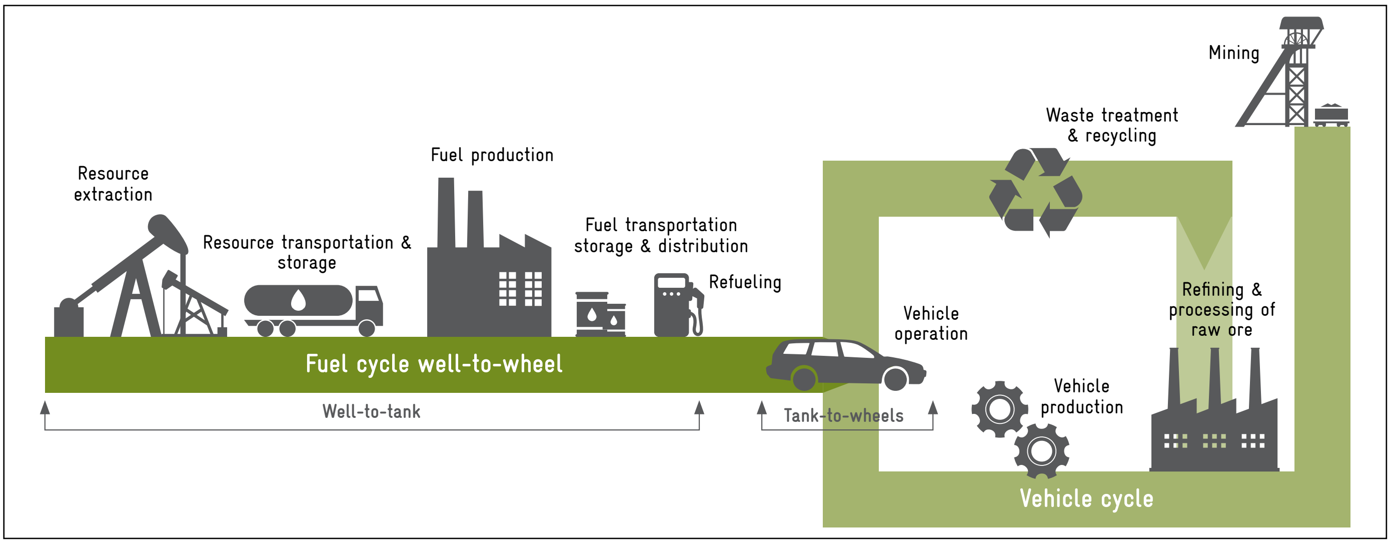



Figure 1: Methodological framework for the LCA

Source: GIZ

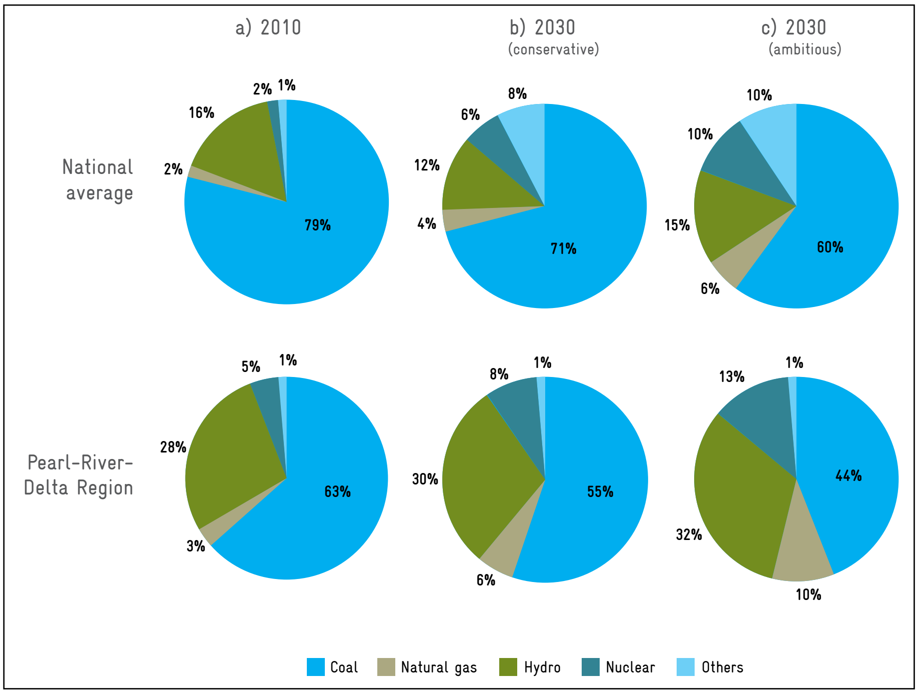



Figure 2: Two electricity mix scenarios for 2030 (conservative, ambitious): The national average and the Pearl-River-Delta Region (South Grid) serve as an example for the six regional grids under study.

pares the energy consumption, greenhouse gas and critical air pollutant emissions of various types of EVs with those of conventional gasoline vehicles. The full LCA includes the fuel cycle and the vehicle cycle:

- The **fuel cycle** can be broken down into the well-to-tank (WTT) and the tank-to-wheel (TTW) analysis. Energy consumption and emissions during the WTT stage are a result of resource extraction, its transportation and storage. Crucial influencing factors are generating efficiency, electricity mix and filter technologies. During the TTW stage, emissions and energy consumption during vehicle operation are considered. The fuel economy and vehicle kilometers traveled (VKT) are the crucial determinants.
- The **vehicle cycle** calculates the overall energy consumption and emissions across the product life by assessing the elements of mining, refining and processing of raw ore; vehicle production processes; waste treatment and recycling.

## Where does the electricity come from?

Limited domestic fossil fuel reserves, serious environmental pollution and increasing public concern have initiated a turn-around in Chinese transport energy and environmental policies. According to current governmental plans, the share of coal in total energy production shall decline from a current 79 % to less than 62 % by 2030 [1], which is even more ambitious than assumed in this study (see scenarios in *figure 2*). These ambitious plans have already found their way into policy implementation: China is leading worldwide investments in renewable energies, having poured the equivalent of 75 billion EUR into this area in 2014 [2] – twice as much as the USA as the runner-up. Despite this, the major sources of electric power are coal, natural gas and hydropower. In the study's baseline year 2010, the coal power share was 79 %, followed by hydropower at 16 %. However, regional differences in China are immense. The Pearl River Delta with the megacities Shenzhen, Guangzhou and Hong Kong source already about one third of their energy from hydropower.

## Electric vehicle market uptake

Aside from the issue of power sources, the share of EVs in the vehicle population is a crucial determinant for the environmental impact of the overall fleet. The projection of light-duty vehicle stock development is determined by gross domestic product, population growth, population density and vehicle control policies. Based on the input data (China's population is estimated to grow between 10.8 and 12.9 % in the next 15 years) the light-duty vehicle population could possibly grow to up to 453 or 560 million vehicles in 2030. For the projection of EV numbers, the study relied on user acceptance derived from hundreds of interviews in China, and on relevant national market development plans. Scenario 1 focuses on the expected development of plug-in hybrid EVs with a market share of 18 % by 2030 (see *figure 3*). Scenario 2 stresses the development of battery-operated EVs reaching 8.6 % market share in 2030.

### Greenhouse gas mitigation potential promising in the mid-term

The lifecycle $CO_2$ emissions were of special interest in the study. The results are shown in *figure 3*. In the baseline year 2010 the lifecycle $CO_2$ emissions of an EV exceeded the emissions of an internal combustion engine vehicle (ICEV) (when using the national grid mix), not least due to significant energy demand in the vehicle cycle. This value decreases in 2015 and is expected to continue to do so in subsequent years due to the higher share of renewable energies and cleaner coal-production technologies. By 2030 EVs are expected to produce 27 % lower emissions over their full lifecycle compared to ICEVs.

Feeding the LCA emission results into the two described vehicle population growth scenarios shows that the $CO_2$ emissions of the overall vehicle population in China are set to continue to increase rapidly this decade (see *figure 4*). Without an increased market penetration of alternative propulsion technologies, the road transport sector could reach an emission level of 794 million tonnes of $CO_2$ by 2030. The percentage reduction in respect to $CO_2$ emission relative to the business as usual scenario is between 5 and 6 % for both of the two vehicle population development scenarios. Substantial $CO_2$ mitigation effects occur from 2020 onwards. By 2030 propulsion technologies could save between 40 and 47 million tonnes of $CO_2$.

### Air quality effects uncertain

Fine particles or particulate matter (PM2.5) pose a large health risk especially in densely populated megacities. They are the main reason for the so called "Airpocalypse" in China. Because of their small size, particulates can easily become lodged deep inside a person's lungs, causing considerable damage. In Beijing, about one third of all local PM2.5 emissions can be attributed to road transport [3].

Various air pollutants were analyzed in the study. EV promotion significantly reduces volatile organic compound and carbon monoxide emissions, but may increase nitrogen oxide, sulfur dioxide and PM2.5 emissions significantly. *Figure 5* displays the per-kilometer well-to-wheel primary PM2.5 and volatile organic compound emissions for hybrids, plug-in hybrids with an all-electric range of 15 or 50 kilometers (PHEV15/50) and battery-powered EVs relative to their ICEV counterpart in China from 2010 to 2030. Well-to-wheel PM2.5 emissions mainly result from upstream energy production. As the power generating efficiency and clean energy production share increases, emissions gradually decrease for all propulsion technologies. By 2030 the well-to-wheel PM2.5 emissions of hybrid EVs and plug-in hybrids (PHEV15) will decrease by 30 % and 14 % respectively. Plug-in hybrids with a longer all-electric range (PHEV50) and battery EVs exceed emissions of a conventional vehicle (ICEV) by 42 % and 91 %.

The principal concern when discussing air pollutants are health effects, especially in an urban environment. As emissions shift from the tailpipe to upstream energy production, not only the quantity but also the location of air pollutants matters. Apart from the EV market share, the impact on urban ambient air quality depends on the location of the energy production as well as meteorological and topographic conditions.

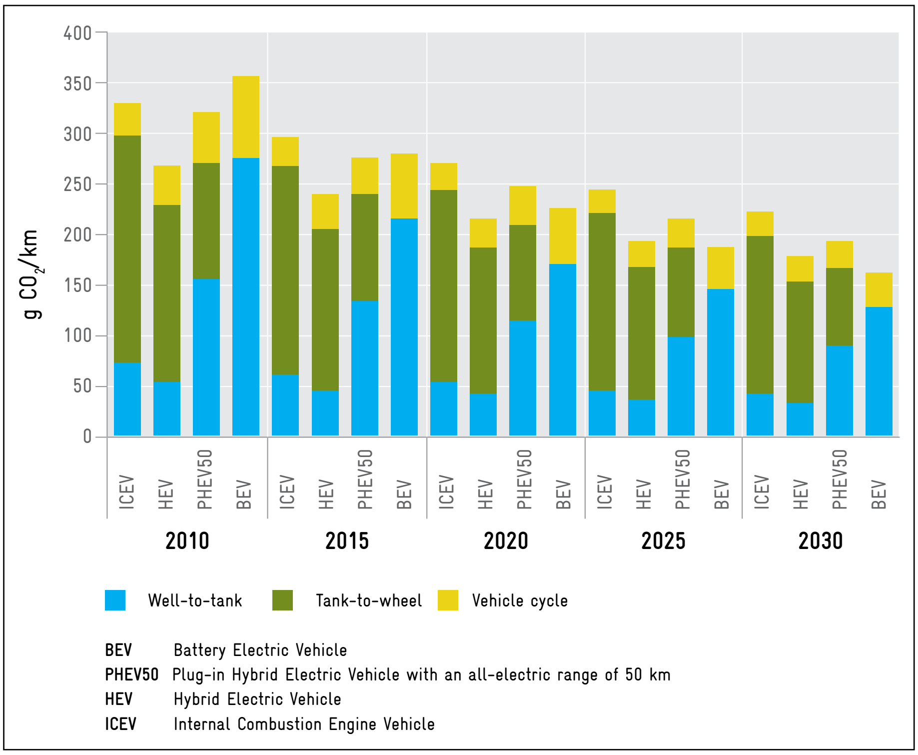



Figure 3: Lifecycle $CO_2$ emissions using different propulsion technologies Source GIZ/Tsinghua

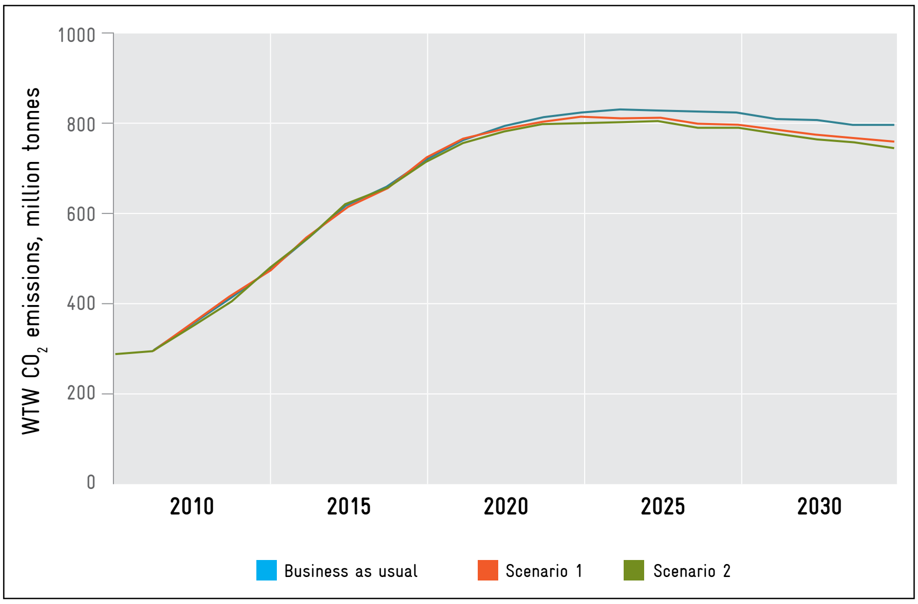



Figure 4: $CO_2$ emissions of Chinese road transport for two market development scenarios of EV Source GIZ/Tsinghua

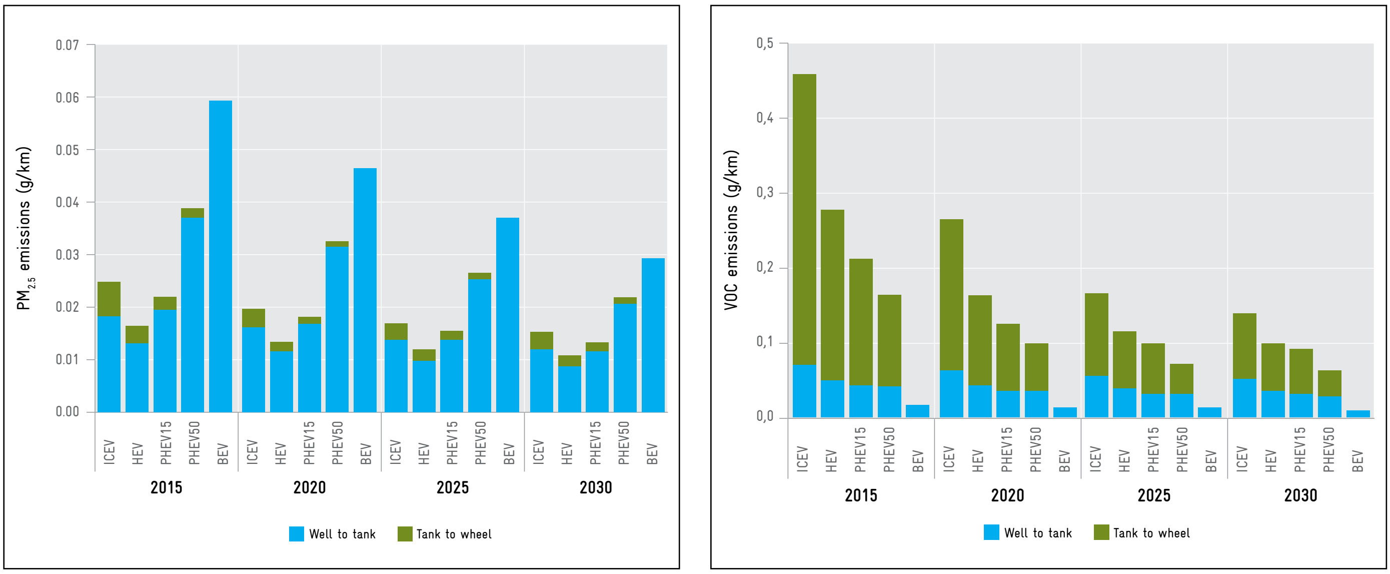



Figure 5: Well-to-wheel PM2.5 and VOC emissions for different propulsion technologies until 2030 Source: GIZ/Tsinghua

## Energy security: a burning topic in China

By 2013, the share of imported petroleum in total domestic oil consumption in China rose to an all-time high of 58 % compared to 33 % in 2000. Beyond its impact on international politics, the dependency on imported fossil fuels has negative macro-economic effects: Volatile fuel prices and the export of domestic value creation lead to economic uncertainty and negative effects on employment. E-mobility in China has the potential to completely decouple the automotive sector from imported fuels. Plug-in hybrids with an all-electric range of 50 km can significantly reduce petroleum consumption by up to 50 %. Given that the share of oil-based electricity generation in China is negligible, battery-powered EVs almost entirely eliminate petroleum consumption.

## Climate protection through e-mobility does not come for free

The LCA results show: Promoting e-mobility is not a low-hanging fruit in the battle against climate change. The long-term mitigation potential of EVs could come at significant abatement and environmental costs today. Nonetheless the LCA also shows that a low-carbon automotive sector is not attainable without EVs. A scenario analysis for the case of Germany comes to comparable conclusions [4]. A low-carbon transformation of the road transport sector is only attainable if EVs are established in the market, if transport demand management is effectively leading to a modal shift and if the share of renewable energy increases substantially.

What are the implications of these results for policy making in China? A comprehensive systemic climate and environmental approach is required beyond the promotion of e-mobility. Now is the time to develop innovative intermodal mobility solutions, improve battery recycling, transform the energy sector and install dust removal and desulfurization technology. If these preconditions are met, e-mobility in China will activate its huge climate and environmental protection potential. To develop a roadmap for a climate and environmentally sound e-mobility is the aim of the Sino-German cooperation project "Electro-Mobility and Climate Protection in China" funded by the German Federal Ministry for the Environment as well as several Chinese Ministries.

Coming back to the initial question: Are the substantial investments in e-mobility justified from an environmental point of view? We believe that the answer is "we currently do not see much of an alternative". Without any doubt the demand for motorized individual mobility in China will not slow down significantly any time soon. The technological lock-in effect of not investing in e-mobility now – to enable it to develop at the same pace as the renewable energies – could therefore be very costly in the long run. Long development cycles in the automotive industry, long innovation cycles for traction batteries and a costly charging infrastructure require early collaboration across industry and the state. If government, car manufacturers, and other stakeholders, such as charge point operators and utilities, fail to drive the required market expansion now, the passenger road transport sector is likely not ready for the necessary decarbonization when the power sector is! ■

[1] The cooperation is funded by the German Federal Ministry for the Environment through its International Climate Initiative, and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and Tsinghua University. The study can be downloaded from www.sustainabletransport.org.

## SOURCES:

[1] Energy Development Strategy Action Plan (2014-2020), China State Council

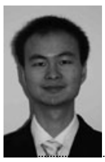
[2] Frankfurt School-UNEP Centre (2015), Global Trends in Renewable Energy Investment

[3] Beijing Municipal Environmental Protection Bureau (2014), http://zhengwu.beijing.gov.cn/

[4] Umweltbundesamt, Öko-Institut (2013), Treibhausgasneutraler Verkehr 2050

**Frederik Strompen**
Project Manager, E-Mobility and Climate Change, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Beijing (CN)
**frederik.strompen@giz.de**

**Christian Hochfeld**
Senior Advisor Sustainable Transport, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Beijing (CN)
**christian.hochfeld@giz.de**



**Ye Wu**, Prof.
Tsinghua University Beijing, School of Environment, Beijing (CN)
**ywu@tsinghua.edu.cn**


Photo: David Alejandro Rendón/Wikipedia

# Urban mobility and quality of life supported by IT

Planning, scheduling, operational control, passenger information, IT system, Latin America

The viability and economic performance of cities depends on the availability and efficiency of public transport. The example of Santiago de Cali in Colombia shows how modern IT systems can contribute to making mobility systems in urban regions future-proof. Within just a few years, IVU Traffic Technologies AG has built up a comprehensive system for planning and scheduling of buses and drivers, operational control, passenger information and billing in Santiago de Cali. The project has revolutionized transport in the city and has been recognized with the UITP Award.

Author: Claudia Feix

Santiago de Cali is a typical Latin American metropolis: around 2.5 million inhabitants, heavy road traffic and, until recently, no regulated public transport. Anyone traveling by foot who wanted to cover longer stretches within the city had to take a taxi or one of the more than ten thousand minibuses plying for business according to a system that was completely incomprehensible to those accustomed to European standards.

Routes, bus stops and timetables? No chance! Instead, the Caleños were prepared to simply stand at the curb, raising an arm to signal to passing minibuses that they wanted a ride. A sign on the windshield showed the destination, thus indicating the general direction the journey would be taking. If passengers were near their destination or at a major intersection where they could change to another bus, they signaled to the driver that they wanted to get off, and the bus stopped (*figure 1*).

Congestion, accidents and traffic jams were part of everyday life. Nobody was able to say in advance when they would reach their destination – the main objective was simply to arrive. Not only did this make journeys within and across the city unpredictable, it was highly inefficient as well. No real control existed over when, where and how many buses were on the road. This resulted in routes subject to high demand being served by many more vehicles than was necessary. Meanwhile, there was a shortage of capacity elsewhere.

## New IT infrastructure for operational control

The administration in Cali decided to take action in order to ease the traffic burden in the city and reduce the associated air pollution. They initiated a large-scale project called "MIO para todos", creating an entirely new public transport infrastructure. Since 2009, modern buses have been operating a Bus Rapid Transit (BRT) system along the main traffic arteries of the city, running on dedicated bus lanes with fixed stops.

The UTR&T consortium was responsible for the construction and operation of this BRT system, called the Masivo Integrado de Occidente (MIO = Western Mass Integrated). The consortium takes care of the ticket outlets, control and communications systems, passenger information and fleet management. UTR&T is committed to sustainable passenger transport on the basis of smart IT systems and cutting-edge technologies. They commissioned IVU Traffic Technologies AG to deliver systems for planning, scheduling and operational control of the entire fleet, equipping the vehicles with on-board computers and providing systems for passenger information at bus stops and on the buses themselves.

Crucial to this decision was the provider's ability to procure everything from a single source. The integrated standard system called IVU.suite met the Colombians' requirements perfectly because it comprises all the software and hardware components required to control the entire operation of a bus company, thus allowing the rapid realization of the project. On this basis it was possible to implement the system in Cali in just a few months and put it into operation on time.

## Design and operation of the system

*Planning and scheduling*

Using the IVU.plan module, the transport providers in Cali are now creating the first systematic timetables, vehicle schedules and driver rosters for public transport in their city – a novelty for both managers and employees, but essential for the stable operation of a modern BRT. Depending on the day and time, the planners define different cycle times according to requirements. Connection planning makes it possible to set up appropriate transfer times at traffic junctions so that passengers do not have unnecessary waits.

Another prerequisite for a functioning BRT are coordinated vehicle schedules and crew rosters that are precisely matched to the timetable. These can also be created and saved in IVU.plan. This allows the integrated planning of vehicle and crew schedules so that all resources can be employed as efficiently as possible. Sophisticated optimization routines are also available for optimum exploitation of the existing potential. Finally, the system transfers the finished plans to the IVU.vehicle and IVU.crew dispatch modules, which manage the daily dispatching of vehicles and personnel.

In Cali, in contrast to other cities, the vehicles are distributed over all existing bus routes. As a consequence, there is no fixed assignment of a bus operator to a particular route, for example. This allows the available resources to be utilized as effectively as possible. In combination with the optimization functions offered by IVU.plan, this has resulted in Cali requiring only 1,000 vehicles for the public transport system to run smoothly. This compares with the 2,700 vehicles that would normally be required according to the rule of thumb that states that 1,000 vehicles are needed per 1 million residents.

**BACKGROUND INFORMATION**

**A textbook example of modernization**

At the 59th World Congress 2011 in Dubai, UITP honored the "MIO para todos" project with the "Research and Knowledge" Award. The judges praised the system as a model for sustainable development of a public transport network in a region that is characterized by excessive private transport, traffic overload and an increase in accident rates.

The following year, the Colombian Parliament honored IVU Traffic Technologies AG for their outstanding contribution to the implementation of the new transport system with the Grand Cross of Alexander von Humboldt.

*Fleet management*

For Cali, one far-reaching innovation involved the control of the ongoing operation. In order to make sure that the timetable was adhered to and the buses departed on time, the municipal transport authority, Metrocali, established a central control room that now maintains a constant overview of the current operating situation and the status of the individual vehicles. For this, the IVU.box on-board computer (*figure 2*), the IVU.cockpit on-board system and the IVU.fleet control center software are used in combination.

Each bus is equipped with its own on-board computer that controls the entire vehicle equipment periphery. The devices


▲ Figure 2: On-board unit IVU.box.touch Source: IVU Traffic Technologies

◀ Figure 1: The old buses that made up what used to be the city's transport system. Photo: David Alejandro Rendón/Wikipedia

Figure 3: MIO buses pass the traffic jams in separate lanes. Photo: MIO

feature a number of interfaces to common analogue and digital positioning and communication systems as well as links to the passenger information systems in the vehicles. The heart of the system is the IVU.cockpit operating software. It collects all data generated during the journey, shows the timetable situation on the driver's display, informs the passengers about the next stop and ensures that there is voice and data communication with the control center.

This means that the dispatcher in the control center knows where a vehicle is located at any point of time and can intervene if necessary. With the new buses, breakdowns are an exceptional event today, and accidents or traffic jams are also becoming a non-issue, thanks to the dedicated BRT bus lane (*figure 3*). However, in case there are disruptions to operations, automatic scheduling functions help find solutions quickly and, for example, ensure that connections can still be made.

***Passenger information and controlling***

Closely linked to this is the dynamic real-time passenger information function – a revolution for the Caleños, who had been accustomed to taking the buses as they came. Today, the current bus departure times can be read off the displays at the bus stops or accessed on the Internet by smartphone. For this the Colombians use IVU.realtime, which is connected directly to the control center and provides the data via standardized interfaces. On top of that, the MIO online trip planner uses IVU.journey to calculate the optimal connection from door to door.

And last but not least, IVU.control has been implemented as a powerful system for the comprehensive evaluation and analysis of the transportation service. Interacting with the IVU.fleet control center software, it captures how many kilometers a bus has actually been driven, and thus makes it possible to accurately divide up the revenue, according to a flexible key, between the individual operating companies. Statistics on punctuality, regularity, connection quality, outages and numerous other parameters provide detailed information on the performance of the BRT and enable the authorities to operate a targeted quality management system.

**Conclusion**

With the comprehensive modernization of its local public transport system, Santiago de Cali has taken on a pioneering role, both on the South American continent and on the international level. Thanks to the consistent use of IT systems, the authorities are now able to comprehensively control the public transport system and flexibly adapt it to current demand. Rides are now on time, passengers receive constantly updated information and the operators are remunerated according to performance rather than with a lump sum – overall, the entire system is now much more efficient and sustainable than previously.

This also benefits the city. The current tally of 900 buses has replaced around 5,000 of the old minibuses. Every day MIO reliably transports around 600,000 passengers to their destinations. Over just a few years since the introduction of the system, the number and density of traffic jams has declined noticeably, and the number of road deaths has fallen by almost 70 percent. And there has been a measurable decrease in air pollution as well. In other words: The quality of life has improved, the threat of gridlock has been averted. ■

**Claudia Feix**, Dr.
Area Manager Latin America, Bogotá,
IVU Traffic Technologies AG
**claudia.feix@ivu.de**


Photo: Stephan Anemüller

# KVB launches an integrated bike rental system

Public transport, multimodal travel, sustainability

In early May 2015, Kölner Verkehrs-Betriebe (KVB), Germany's fourth biggest municipal public transport provider, launched its bike rental system in cooperation with nextbike GmbH. With a total of 950 bikes available, users can now plan their journeys more flexibly because they can combine bike use with a bus or tram journey. This project is part of the strategy of the city of Cologne and the KVB to foster eco-mobility by providing convenient and easily accessible public transport, cycling, car sharing and walking options.

Author: Stephan Anemüller

Having operated the bike rental scheme for four months now, the KVB is very satisfied with this "third business field". There are nearly 50,000 registered users and an average of about 1,000 rental transactions per day. While all population groups are represented, the share of jobholders and students is especially high. Obviously, it is still too early for a first evaluation, but the general trend points in the right direction.

People's mobility habits are changing, particularly in large cities: Urban dwellers want to stay mobile, but do not necessarily want to own a private car. Many people use public transport or mix their own 'mobility cocktail' consisting of bus and/or rail combined with rental bikes or cars. That is why the bike sharing offer is a practical and important contribution to the "Cologne mobile in 2025" strategy.

In the inner city of Cologne as well as in its Deutz, Mülheim, Braunsfeld, Lindenthal and Ossendorf districts, people can flexibly rent KVB bikes at the roadside and return them within any of the areas served (*figure 1*). At about 25 central locations such as Neumarkt, University of Cologne, Rudolfplatz, Zülpicher Platz, Breslauer Platz/Cologne Main Station, Ebertplatz, Wiener Platz, Mülheim station and the "Sparkasse" at Butzweilerhof, bike rental stations have been established with up to ten bikes each. Every day a service team from the cooperation partner nextbike checks whether the intended number of bikes is available at each station, whether the bikes are parked properly and whether the number of available bikes meets local demand. In May, an additional KVB bike station for 20 bikes was put into operation at the Carlswerk site at Schanzenstrasse in Cologne-Mülheim.

By the end of 2017, there will be up to 100 KVB bike stations at attractive locations. The KVB, the city of Cologne and the district agencies will jointly decide on the locations. Nahverkehr Rheinland GmbH (NVR), a public transport association for the southwest of North Rhine-Westphalia, supports these bike stations with about EUR 600,000. This support was contingent on the creation of a standardized access function for all chip card holders within the Verkehrsverbund Rhein-Sieg (VRS), the transport providers' association for the Rhine-Sieg area. KVB's new offer has been integrated into the VRS scheme at the end of January 2015, which means that the VRS chip cards are now included in KVB's bike rental scheme (*figure 2*).

The first 30 minutes of each journey are free for KVB customers holding VRS chip cards (e.g. jobholder tickets, monthly tickets or 60+ senior citizen's tickets). Longer journeys cost € 1 for every subsequent 30-minute period. Customers who do not have VRS chip cards have to pay EUR 1 for the first 30 minutes also. All customers pay EUR 9 if they rent the bike for the entire day.

Every customer has to register as a user before renting a bike for the first time. Customers with a VRS chip card simply hold their chip card up to the computer on the bike, enter their mobile phone number twice and accept the General Terms and Conditions (AGB) of the KVB. Then they are sent a PIN via mobile phone, which is their permanent access key in conjunction with the VRS chip card. The bike is released after these few steps. If VRS customers want to rent a bike for longer than 30 minutes, they have to sign up as users on the web page www.kvb-rad.de and fill in the registration form and indicate the desired means of payment. The web page also provides detailed information on the KVB bikes and their use.

A customer without a VRS chip card registers on the web page www.kvb-rad.de or via the KVB mobil app. The nextbike offers have been integrated into the KVB app so that the customer does not have to download the nextbike app. Available bikes can be located via this app. Moreover, it is possible to register as a user by phone via a hotline.

The customers, the KVB and nextbike can learn from one another how to optimize the offer. In the first weeks of operation, project manager Frank Gassen-Wendler talked to a number of users by phone. Some customers had parked the bikes out of the areas served and had to pay an extra fee. Other customers had not completed the return procedure so that they were charged the fee for a very long journey. The project manager was also very interested in hearing about the first customers' experience with the new bike rental offer.

By now, the software has been modified to simplify the return procedure. Moreover, improvements have been made to the user interface showing the current offer in the KVB app and on the web page.

### Effective advertising promotes the offer

KVB has succeeded in getting Peter and Stephan Brings, members of the German cult band "Brings", to promote the new offer. In the promotional video[1], Peter Brings, impersonating James Bond, is presented his new 'official' vehicle – a KVB bike. And Stephan Brings, known to be cycle enthusiast, is the protagonist of the print campaign (*figure 3*). A flyer with a print run of 30,000 has been distributed in the KVB vehicles, at customer centers, at information desks and via cooperation partners. Postcards, posters and stickers in buses and rail vehicles round off the advertising campaign. In addition, two animated videos intended for regular and occasional customers respectively, demonstrate how simple and easy it is to rent and use the bikes. These videos have also been published on YouTube.com/kvbag and are available on the particular web page www.kvb-rad.de.

### The offer focuses on the University of Cologne

The University of Cologne is a priority area for the launch of the bike rental system. The university has about 50,000 students, 7,600 employees and a very large campus. The KVB bike is an excellent mode of transport to travel quickly form one university building to another. There are three central locations, the students' service center, the cafeteria/sports center and the faculty of human sciences, which are being served daily by the service team. It is intended to establish stationary bike rental facilities at these locations in cooperation with the university. Moreover, the university plans to set up its own bike station including a repair workshop and up to 2,000 parking spaces for private bikes.

Within the scope of a pilot project, the students of the University of Cologne can use the KVB bikes under the same conditions as KVB's regular customers. The KVB and the university plan to issue the semester tickets for students on chip cards. Until then, the students can use their university e-mail addresses to be granted the conditions of the regular customers, i.e. they can use the KVB bikes for free for up to 30 minutes per journey.

A customer group analysis has revealed that young people are not the only ones to use the KVB bikes. Other sectors of the population are also very interested in the new offer. This is in line with the results of an evaluation report prepared by the German Federal Government. This report analyzes the state of bike rental schemes in other cities and rural districts. The users of the KVB bike offer can be grouped according to the various kinds of tickets used, i.e. semester ticket, job ticket, 60+ senior ticket etc.

### Cologne mobile in 2025 – Strategy for sustainable transport development

In 2014/15, together with the local transport companies and other organizations in Cologne, the municipality of Cologne prepared the "Cologne mobile in 2025" strategy as the basis for a future action plan. The objective of the strategy and the action plan is to keep traffic flowing in the metropolitan area of Cologne and thus to ensure the mobility of citizens and companies alike.


Figure 1: KVB bikes are available at central locations
Photo: Stephan Anemüller


Figure 2: Access using a VRS chip card
Photo: Fotostudio Heupel


Figure 3: The KVB attracts attention with extensive poster advertising
Photo: Stephan Anemüller

Figure 4: Public transport is the backbone of urban transport
Photo: Stephan Anemüller

The "Cologne mobile in 2025" strategy focuses on the development of eco-mobility. Therefore it promotes public transport, cycling, walking and other environmentally friendly transport modes. The mixture and – above all – the possibility of combining these mobility options help reduce the number of journeys by private car and thus support the city in reaching its various climatic and environmental objectives and in ensuring that there is sufficient road space for freely flowing traffic.

The successful establishment of eco-mobility presupposes the implementation of intelligent and above all sustainable measures for the long term. Innovative approaches are helpful as they can influence people's lifestyle and traditional behavior ("the convenient car on the doorstep", "status shown with an expensive private car in the company's car park" etc.). Bike rental systems and car sharing are such innovative approaches.

The KVB serves more than 800,000 passengers per day. Thus, its light rail and bus systems are the backbone of urban mobility. If the transport offers of the KVB did not exist, Cologne would be "immobile" already today due to permanent traffic gridlock. However, despite its about 60 lines and 900 stops, the KVB cannot connect all destinations door-to-door. For many road users, the last few hundred meters or the last mile are the reason why they do not shift from the private car to public transport. Furthermore, in the evening and at night, public transport systems cannot offer the same short intervals of service as during rush hour, for obvious economic reasons. As a result, many people who would like to go by bus or rail still do not use the public transport offers of the KVB.

All over the world municipalities and transport companies are planning or optimizing bike rental schemes in order to minimize their local mobility problems at low cost and in an environmentally friendly way. It certainly makes sense to combine public transport with other environmentally friendly transport modes to foster the eco-mobility. The cooperation between nextbike and the KVB is one element for implementing the "Cologne mobile in 2025" strategy. Ideally, the threshold to the entire public transport, including the bike rental scheme, must be as low as possible, for instance by making public transport accessible with a single ticket. So bikes are a real supplement to bus and rail. ■

1 The video has been published on YouTube https://youtu.be/KFsdhnNrUE8 and is broadcasted via KVB's facebook channel.

**Stephan Anemüller**
Media spokesman, Kölner Verkehrs-Betriebe (KVB), Cologne (DE)
**stephan.anemueller@kvb-koeln.de**

# Park and bike

## Selected solutions for bike parking

## Velowspace: Automated 24/7 bike rental system

The Dutch bike rental company OV-Fiets uses Velowspace, a fully automated rent-a-bike system with an integrated carousel, to increase the availability of rental bikes at railway stations and promote the idea of "green" mobility in urban areas. The system is currently in operation at 95 stations throughout the Netherlands.

The system hardware consists of a fully automated carousel inside a round container for tethering up to 24 bicycles. Depending on whether the client wishes to collect or return a bicycle, the carousel turns a bicycle or a free space toward the automatically controlled door. After user authentication – based on different technologies such as Mifare cards, Skidata (bar-code), swipe cards and others – the door opens to give access either to an empty return cell or a cell containing a bike.

For returning the bike, the user registers by means of the subscription card again and the system asks whether the bike is in good condition or needs repair. If the bicycle is defective, it will be blocked until repaired.


Velowspace units installed at mobility hubs such as train station forecourts make it easier and more convenient for travelers to change from or to a bicycle, whether spontaneously or as part of their journey plans. The modular design is sufficiently flexible to allow for stand-alone installation or stacked configurations.

*red*

www.lo-minck.nl

## Wöhr Cycle – a tower full of bicycles

Wöhr Cycle is the name for the new technology recently developed by the company Wöhr, which is known as a supplier of automated car parking systems. The automated parking garage for up to 128 bicycles is available as tower or pit version. All standard bicycle types, including pedelecs of up to 30 kg, can be parked securely and with minimum space requirements in the easy-to-use Wöhr Cycle tower.

The user simply places the bike on a rail in the transfer cabin and enters the storage request at the user terminal. The system pulls the bicycle into the tower and closes the door. As the bikes are stored behind locked doors – and below ground for the pit version – vandalism and theft are practically excluded. For retrieval, users hold their chip


up to the user terminal and the system selects the corresponding bike. After 16 seconds on average, the bicycle is available in the transfer cabin – with the front wheel to the front.

Various operation and payment modes can be realized: Cycle towers installed on public squares can be equipped with terminals allowing different means of payment such as bank or credit cards, smartphone apps or special prepaid cards. For towers in a residential or office complex, every user receives a personal chip device, comparable to an electronic key or access ID, which is used to initiate any bike storage or retrieval transaction.

*red*

www.woehr.de

# Ready to go

## MTU Hybrid Drive proves market readiness

Hybrid drive systems, emission-free driving, noise emission, customized solutions

Over three years, MTU Friedrichshafen GmbH ran trials with its Hybrid Powerpack, logging 15,000 km to verify its reliability and readiness for everyday operation. Result: MTU Hybrid technology is ready for the market. On local routes in particular, MTU's advanced rail drive system offers considerable potential for increasing economic efficiency and reducing emissions in rail transport. In purely electric drive mode in particular, hybrid technology enables emission-free local travel in urban areas, underground stations and tunnels. In addition, the combination of electric drive and diesel engine helps keep trains on time and makes it easier to make up for delays.

Authors: Benjamin Oszfolk, Matthias Radke, Matthias Kasch, Yvonne Ibele

The test vehicle was a Series VT642 Deutsche Bahn railcar, which had been converted to hybrid drive technology. Between January and March 2015, trial journeys were run on a 37 km line section including 13 stopping points operated by Westfrankenbahn near Aschaffenburg in Germany – and on a 23 km section including 9 stopping points operated by Staudenbahn in Augsburg, Bavaria.

The vehicle was equipped with a comprehensive range of measuring technology to allow recording of system parameters such as current, voltages, GPS signals and diesel consumption. In addition, acceleration sensors were installed to calculate and monitor the forces acting on the vehicle. And a dedicated virtual driver system was developed to facilitate comparison of the various hybrid travel strategies with the diesel-based reference model. The virtual driver system included a monitor screen for the human driver. This display was used to continuously show the optimum speed required to remain on schedule given the current travel strategy, and it relayed control commands to the train driver.

Prior to the actual test runs, a simulation environment developed in-house was used to run whole-vehicle simulations. Besides various travel strategies including peak speed with runout, moving off under electric power, and combustion engine shutdown, four additional strategies were investigated. Further parameter variations were implemented in simulation mode aiming to reduce fuel consumption and $CO_2$ emissions.

The tests proved that the Hybrid Powerpack is able to achieve in practice the 18 % fuel savings compared to pure diesel operation which had been calculated during simulations (see *figure 1*). The illustration shows vehicle speed, the energy storage system's State of Charge (SoC) and the accumulated fuel consumption of a given drive system over the travel period.

To ensure comparability for all travel strategies, at the end of each test run the SoC had to match the initial value at the start of the test run. For this purpose, after the completion of each test run, the diesel engine was used to recharge the energy storage system up to the initial SoC. The additional fuel consumption involved was factored in when determining total consumption.

The investigations and test results show that in comparison to conventional drives, the economic efficiency of the hybrid drive can be increased even further on routes involving multiple stopping points and higher speeds, and that further optimization can yield fuel savings of 25 %.

In addition to runs for the purpose of consumption measuring, noise emission measurements were also conducted in line with TSI Noise. As had been forecast, it proved possible to shut down the diesel engine when the vehicle was stationary (i.e. at stations), thereby reducing the noise level by up to 21 dB. The benefit of reduced noise levels was also obvious when the vehicle moved off, as it was driven purely electrically over the first few meters and the diesel engine was only cut in at a later point.

The test runs thus confirmed that, on local journeys in particular, hybrid technology contributes to more environmentally friendly and more efficient drive solutions as compared to conventional systems. In addition, the availability of simulation tools means that optimum hybrid drive configurations can be individually calculated for each route profile and each timetable and that reliable statements on achievable fuel savings can be formulated in advance.

### Hybrid drive components – Integration in the vehicle

In essence, the core components of a hybrid drive system are a combustion engine, an electrical machine, power electronics, an energy storage system, drive control equip-

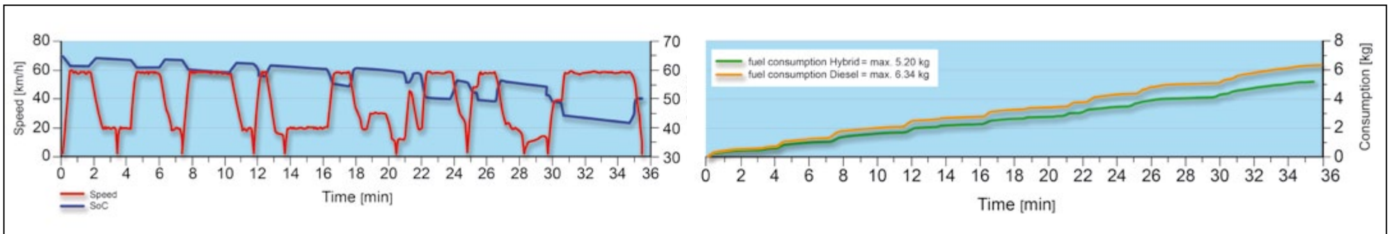



Figure 1: The left figure shows vehicle velocity in red and SoC gradient in blue on the Staudenbahn track from Oberneufnach to Magertshausen. The rigth figure shows diesel fuel consumption in orange and hybrid fuel consumption in green. Total savings amount to 18 %.

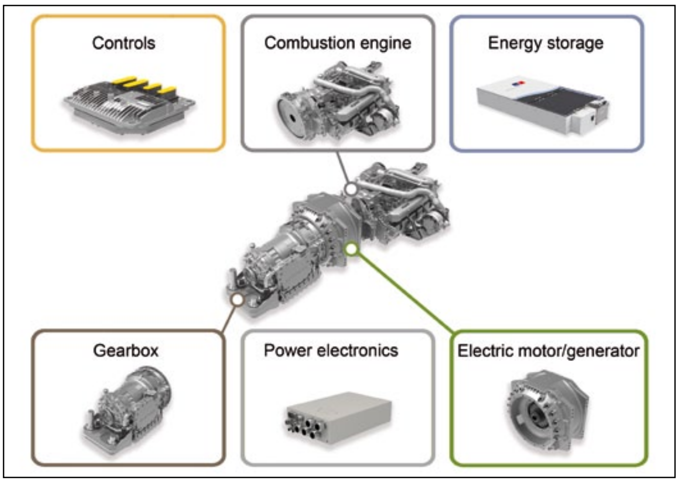



Figure 2: Modular set of components including combustion engine, energy storage, electric motor/generator, power electronics and gearbox

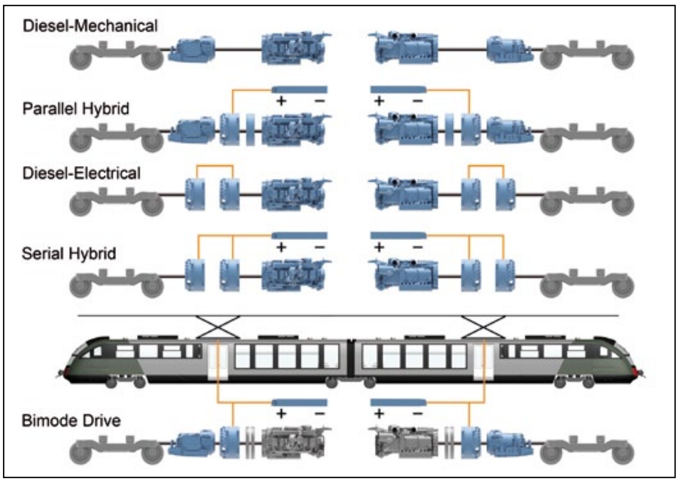



Figure 3: Drive system configurations: Parallel hybrid based on the diesel-mechanical drivetrain, serial hybrid based on the diesel-electric drivetrain. By connecting the hybrid system to the overhead line, a vehicle with bi-mode drive can be realized.

ment and – depending on the configuration – a gearbox (see *figure 2*).

To enable the realization of a range of hybrid drives, a modular component system was developed. This makes it possible to tailor the drive system to suit the vehicle and to cater for customer-specific operating factors such as timetables, route, etc.

In principle, there are three viable installation concepts (see *figure 3*). The roof-mounted design variant places the energy storage system on top of the vehicle. Fluctuating ambient conditions in the roof zone are irrelevant here as the energy storage system always has its own cooling system. Integration of the energy storage system in the vehicle's own existing cooling system is also an option. The underfloor design variant involves fitting the energy storage system in the underfloor Powerpack compartment, but this variant requires the availability of adequate space and is primarily suited to new vehicles. Where neither roof mounting nor underfloor mounting are possible, the energy storage system can be accommodated in the vehicle interior. Its modular design provides a high degree of flexibility, both in planning new vehicles and for the conversion of existing rolling stock.

## Drive concepts at vehicle level

Apart from the fuel savings they offer, hybrid-drive vehicles bring a number of other functional benefits. Since hybrid-drive vehicles have both an autonomous diesel drive and an electric drive, they open up additional potential for future uses. A subsequent transition to a bi-modal vehicle requires only the integration of a pantograph in the intermediate electric circuit of the hybrid drive. A vehicle benefitting from this configuration is able to operate at high levels of energy efficiency on non-electrified routes in hybrid mode (i.e. drive system utilizing the diesel engine, the electrical machine and the energy storage system) as well as on electrified lines driven purely by the electrical machine powered from the overhead lines.

*Figure 3* shows possible combinations:

- Diesel-mechanical drive
- Parallel hybrid
- Diesel-electric drive
- Serial hybrid
- Bi-modal hybrid

Vehicles with bi-modal hybrid drive systems benefit from particularly flexible application capabilities. Bi-modal hybrid vehicles offer fleet operators and vehicle owners alike significant flexibility with regard to vehicle utilization. Consequently they can play a key role when it comes to the new allocation of route contracts.

## Economic aspects

During the trial runs, the economic efficiency of the MTU Hybrid Powerpack was verified under actual working conditions. Calculated over the entire lifecycle of the unit, the procurement cost of the Hybrid Powerpack represents only a small fraction. Depending on the drive type, fuel costs for the Powerpack make up between 50 % and 60 % of its lifecycle costs. With a hybrid drive, the largest part of fuel savings is achieved through energy recuperation and the use of the energy recovered for acceleration. Further fuel savings are achieved because hybridization means that electrified auxiliary drive units can now be efficiently powered. The economic efficiency of the hybrid drive is therefore particularly high on routes with multiple stops, making amortization possible within just a few years.

## Summary

Hybrid technology for rail applications is market-ready. Based on the Type 6H1800 engine, MTU's Hybrid Powerpack demonstrated its reliability throughout a comprehensive program of test runs. The tests also confirmed prognostic results obtained from simulations. As a result, customers can expect reliable statements in areas such as economic efficiency, fuel savings, and reduced noise and exhaust emissions. What is more, customized hybrid solutions are feasible: The modular system combining different drive elements can be configured in line with individual customer specifications, generating the maximal benefit for the application and the customers.

**Benjamin Oszfolk**, Dipl.-Ing. (BA)
Research and Technology Development, Drive Systems Development,
MTU Friedrichshafen GmbH,
Friedrichshafen (DE)
**benjamin.oszfolk@mtu-online.com**

**Matthias Radke**, Dipl.-Math.
Research and Technology Development, Function Development,
MTU Friedrichshafen GmbH,
Friedrichshafen (DE)
**matthias.radke@mtu-online.com**

**Matthias Kasch**, M.Eng.
Research and Technology Development, Drive Systems Testing,
MTU Friedrichshafen GmbH,
Friedrichshafen (DE)
**matthias.kasch@mtu-online.com**

**Yvonne Ibele**, B.A. International Business
Sales Rail, Economic Feasibility,
Hybrid Powerpack Project,
MTU Friedrichshafen GmbH,
Friedrichshafen (DE)
**yvonne.ibele@mtu-online.com**


Figure 1: DB Schenker Rail AG is currently installing Leader systems in 300 of its locomotives
Photo: Deutsche Bahn AG/Jochen Schmidt

# How can trains operate more energy-efficiently?

Energy efficiency, driverless freight trains, train control system

**Faced with rising energy costs, fleet owners are increasingly turning to the Leader driver advisory system (iCOM Assist) to improve the overall efficiency of rail vehicle operations. The system uses route, train and timetable data to calculate the best options to save energy, and provides the train driver with relevant recommendations. These can result in fuel savings of more than 10%, as well as reduced wear and tear from in-train forces. Leading European freight operator DB Schenker Rail AG is currently installing Leader systems in 300 of its locomotives.**

Author: Dirk Seckler

With decades of experience under his belt, the locomotive engineer is initially skeptical: His train still has several kilometers to climb before it will reach the top of the incline, but the driver advisory system installed in his cab for testing purposes has prompted him to reduce traction completely. He shakes his head doubtfully, but follows the system's instructions. Under its own momentum the train glides effortlessly over the summit, and arrives on schedule without wasting fuel. This also avoids an unnecessary build-up of kinetic energy that would have merely been lost again during braking.

Such scenarios are not unusual with *Leader* – even experienced drivers are surprised by the accuracy of the system's recommendations.

### The learning curve continues: improvements even with experienced drivers

Scenes like this will soon be commonplace in countless locomotives belonging to DB Schenker Rail AG. After several months spent putting the advisory system through its paces on a variety of routes and under a range of demanding conditions, the logistics specialist was finally convinced that the system could help even highly experienced drivers reduce energy consumption on their trips– and the decision was made to install Leader in 300 of the company's locomotives (*figure 1*). In more than six months of tests under real operating conditions, Leader has demonstrated that it can reduce total energy consumption and $CO_2$ emissions by 10% or more. In-train forces are also cut by about 50%, thereby reducing wear and tear, especially in long freight trains. Low average speeds also make efficient use of the buffer time built into every arrival schedule. And punctual train operations automatically increase track capacity.


Figure 2: Leader driver advisory system – tablet Photo: Knorr-Bremse

### Algorithm calculates maximum efficiency.

At the heart of the system is an algorithm, familiar from Nasa's Mars Exploration Rover Mission, combining information on speed, distance and time. The basic information is drawn from a database with parameters related to the train, track topography and timetable. A GPS receiver provides real-time information on location and speed (*figure 2*).

Allowing for speed restrictions, waypoints and train dynamics, the algorithm calculates in real time the most energy-efficient drive strategy and supplies the driver with prompts via an in-cab display that uses clear symbols for maximally intuitive and user-friendly operation.

The 300 Leader systems already in operation are still to some extent experimental: What information does the locomotive engineer require? When should it be provided? How much in advance should it be made available? And how is it best presented? Several versions of the man-machine interface are currently under evaluation.

With 12 to 18 months, the average amortization period for Leader is relatively short, and rising energy prices are liable to shorten this even further. A back-office application with a range of analytical options is available, and a 'plug and play' function makes retrofitting easy. Since, in Europe, the system only uses the locomotive's electrical supply and does not intervene in the control functions, no licensing is required.

Figure 3: Rio Tinto ore train
Photo: Rio Tinto

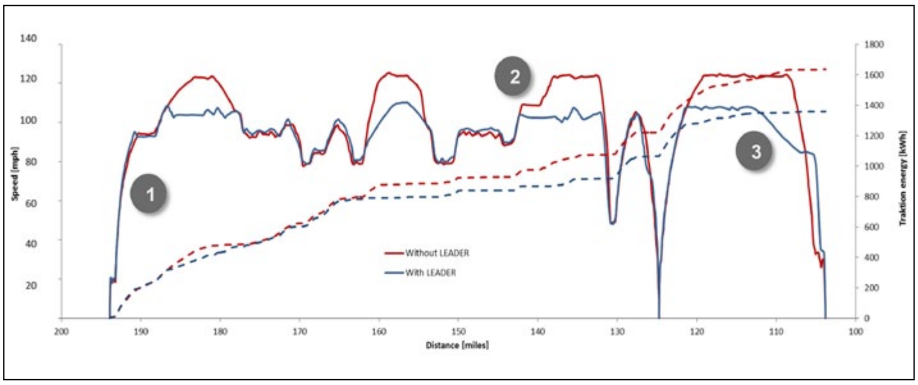



Figure 4: A comparison of operational data with and without Leader underlines the huge savings potential in passenger trains.
Photo: Knorr-Bremse

### Deployment in the North American freight transport market

The system was first launched in North America, where the railroad network, despite its length of 210,000 km, is regarded as one of the most profitable and cost-effective in the world and there is considerable interest in Leader on the part of freight operators.

For good reason: The longer and heavier a train, the higher the benefit of the advisory system, because a heavy train consumes large amounts of fuel every time it moves off again after stopping. Such heavy-haul trains are found not only in North America and South Africa but also in north-western Australia, where many mining companies operate their own fleet to transport minerals to deep-water ports on the coast.

### Driverless freight trains

In Europe, the Leader application merely provides the locomotive engineer with prompts, whereas the system in North America already offers a degree of semi-automated operation comparable to the use of an autopilot on an airplane. However in cooperation with the Australian mining company Rio Tinto, Knorr-Bremse is now going one step further and trialing the world's first fully automated heavy-haul freight train. Rio Tinto is implementing AutoHaul®, using a version of the Leader system developed by Knorr-Bremse's North American subsidiary New York Air Brake (NYAB) as well as software from Ansaldo's Automatic Train Operation and Automated Train Protection systems (*figure 3*).

This application upgrades the functionality of Leader from a purely advisory role to a full-fledged train control system. The active communication links to the network and train control systems are already available in current versions using the core software, but up to now the data were merely passed on as recommendations or put into operation by a semi-automated control system. Now the train will operate completely automatically.

For fully automated control, the technical requirements are much more stringent – as are the safety standards, which is why the entire software program is undergoing a complete revision in line with Cenelec standards.

The underlying algorithm is identical for both freight and passenger operations, and in principle the basic functionality is also the same. But the details of configuration and prioritization differ and need to be individually programmed according to the specific operational scenario. Thus, for example, adherence to the timetable has higher priority for passenger operations than for freight. And the system only recommends that the train be allowed to coast if there is clearly an adequate time buffer. In terms of energy consumption and wear this makes more sense than maintaining speed and then braking upon entering the station.

Leader systems are currently installed in some 5,000 trains worldwide and are also becoming increasingly popular for passenger operations, for example in Israel (*figure 4*). In the UK, Leader systems have recently been retrofitted to diesel multiple units operated by London Midland and Southern, members of the Go-Ahead Group. ■

**Dirk Seckler**
Head of Sales for RailServices, Knorr-Bremse Systeme für Schienenfahrzeuge GmbH, Munich (DE)
**dirk.seckler@knorr-bremse.com**

# Automated parking systems – Operation and practical experience

Parking space, automated parking systems, planning and specifications

Automated parking systems have been available in various forms since the 1920s. Nevertheless, the total parking capacity they provide remains limited. Due to the relatively satisfactory parking space supply, the demand for automated parking is quite low in Germany. Approximately 10,000 parking spaces are provided in a total of 200 automated parking systems. Due to their mostly non-public use, their existence is not widely known. Far more parking spaces, for around 1.7 percent of the country's total vehicle stock per January 1, 2015, are available in mechanical parking systems, which are not fully automated. Abroad, German manufacturers have also realized systems with higher numbers of parking spaces. The following article gives an overview of today's operation and planning.

Author: Ilja Irmscher

Automated parking systems are parking facilities with vehicle-transfer systems that are capable of transferring incoming vehicles automatically to parking spaces. They are classified in the EAR 05 [1] and VDI 4466 [2] guidelines. Strictly speaking, automated parking systems are mechanical parking systems with automated and electronically controlled parking procedures that start and end at the interface of the transfer cabin. All that users are required to do is leave their vehicle in a transfer cabin and confirm that it has been left in a system-compatible condition (i.e. with the engine turned off, doors, windows and hatches shut, activated handbrake, gear settings in first or reverse gear for manual gear shift vehicles, and deactivated alarm system). Exiting the transfer cabin after the parking period is also performed manually by the users themselves. All other entry and exit maneuvers are performed automatically.

The use of automated parking systems requires prior briefing of drivers, and intuitive user guidance ensuring maximum possible operational safety. These parking systems must offer on-call expert support, which can be provided by the car park attendant, the car park supervisor, or by reception facilities for instance. For this reason, automated and also mechanical parking systems are preferably frequented by fixed user groups. Their public use is rare in Germany.

## Use and advantage

In Germany these facilities are built and used if the required and economically viable number of parking spaces cannot be provided, at the desired quality levels, by using purely structural means and conventional systems. In many dense urban locations, above-ground space is expected to be kept free for other primary urban and civic uses, resulting in the fact that a high number of car parks in general, and automated parking systems in particular, are built underground, at significantly higher costs than building them above ground.

One of the main advantages of automated parking systems is the fact that they require less floor space and building site space. They are particularly advantageous when the available floor space in buildings on small lots is so limited that it is impossible to build a complete parking access lane with a user-friendly ramp. The more efficient use of floor space by automated parking systems is primarily due to the replacement of ramps by vertical conveyors, and a deeper, multiple-row layout. Moreover, clearance in the holding areas needs only be high enough to fit actual vehicle dimensions, resulting in additional space savings.

## Permissible vehicle dimensions

To make full use of existing floor space, automated parking systems are designed to meet precisely defined vehicle dimension requirements, including certain reserve margins, and not built to accommodate vehicles of all and any dimensions, but only those relevant to a particular location, use, or host building. *Table 1* shows the maximum vehicle dimensions (including protruding parts such as extended external

| Maximum car park-compatible dimensions | Europe | | USA, Middle East |
|---|---|---|---|
| | Standard case | With increased weight | (excluding large pick-up trucks) |
| Total laden weight | 2,500 kg | 3,000 kg | 3,200 kg (ca. 7,000 lbs) |
| Height | 1.70 m/2.,00 m ≤ 75%/≥ 25% | 1.70 m/2.10 m ≤ 75 %/≥ 25 % | 1.70 m/2.10 m (ca. 67''/83'') ≤ 67 %/≥ 33 % |
| Length | 5.25 m | 5.35 m | 5.70 m (225'') |
| Width with external mirrors | 2.20 m | 2.30 m | 2.30 m (90'') |
| Ground clearance, minimum manageable dimensions | ≤ 80 mm | ≤ 80 mm | ≤ 80 mm (3'') |

Table 1: Recommendations for maximum vehicle dimensions to be accommodated by automated car parks

mirrors, roof antennas and trailer gear) for car park construction projects in Europe and other regions. These dimensions ensure that nearly all currently available limousine and estate car types can be parked in automated parking systems. To meet the demand for parking spaces for vehicles with larger than car park-compatible dimensions, it may be recommended to allocate some conventional parking spaces on the entry level, for example. It must also be taken into account that the largest permitted car park-compatible vehicle dimensions represent absolute limits that must not be exceeded, as this would otherwise pose the risk of collision between vehicles and system parts.

| Parking system as per EAR 05 | Storage principle | Load-lifting system |
|---|---|---|
| Parking shelves | Static/ in multiple-fold storage systems partly dynamic | Parking pallets/pallet-free |
| Pallet shifting system | Dynamic | Parking pallets |
| Circulating system | | |

Table 2: Storage principles and load-lifting systems of automated parking systems

## Stacking principle

An important differentiating feature of automated parking systems is the stacking principle. In cases where vehicles remain stationary in their respective parking spaces during the entire parking time and are being shifted only for stacking and retrieval, we speak of so called static systems. In dynamic systems, on the other hand, the vehicle conveyance system doubles as parking space provider, resulting in the fact that retrieval of one vehicle requires prior shifting of other vehicles. *Table 2* shows a classification of automated parking systems according to the stacking principles and loadbearing systems used.

## Parking procedure

The actual parking process starts with a simple action after drivers have alighted from their vehicles and left the transfer cabin: The respecting parking pallet is taken over by the system and placed into a shelved space. In sliding pallet systems, the pallet is brought into circulation, permitting a vehicle to park on a vacant pallet. As a rule, a parking process typically ends with the provision of an empty pallet in the transfer cabin, ready for the next user.

Depending on local conditions, vertical conveyors and horizontal conveyors as well as turntables can additionally be employed. Manufacturers are basically free to choose the working mechanism of their conveyor technologies and other technical details, while adhering to the applicable basic technical norms and safety standards.

In pallet-free systems, the parking process proceeds in a similar manner for drivers. Vehicles are driven onto a completely flat transfer area or into a transfer device, which requires precise positioning for load-lifting. The principal difference lies in the technology employed for conveyance and in the resulting system features.

In cases where entry and exit of parking spaces take place in opposite direction to the driving direction, turntables are used to turn the vehicle around even before it is placed in the car park to ease its later exit. This allows vehicles to exit the transfer cabin facing forward. In parking towers with centrally located storage and retrieval systems, turntables are located within. Turntables are also required if the direction of the vehicle holding space is not parallel to the parking direction.

When a vehicle is to be retrieved, swiping the corresponding identification element or holding it up to a card reader activates the vehicle retrieval process. Following the removal of the vehicle by the conveyor system, the vehicle is placed in the transfer cabin, ready to be driven out by the driver. If desired, users can alternatively also simply load or unload items from the vehicle and subsequently send it back to the holding area.

## Planning automated parking

As experience shows, automated parking systems require specialist knowledge during all phases from planning to operation, to allow them to be efficiently used as mature technical solutions. It must be noted that there are basic differences in the qualitative, technical safety-related and operational requirements in various product markets and in terms of the available parking systems. These specific features are determined by the following factors, among others:

- Strict application of the applicable EN norm in the areas where in force, resulting in high safety standards for users and the provision of automatic gates, locking devices, as well as devices protecting the users against falling, getting stuck and tripping, and other similar requirements, which contrasts with other markets that mostly tolerate larger residual risks;
- Operation by briefed user circles, a car park attendant or by the public;
- Comfort and safety in the transfer cabins;
- The value of architectural integration;
- The desired system dynamics and redundancies;
- Low-noise operation based on modern construction methods and acoustic decoupling from the building structure;
- Availability rates as per the relevant VDI norm (minimum requirement: 99 %) and reliability;
- Service system based on qualified event recording, tele-service and remote access while meeting local safety regulations (generally with local staff support for additional risk identification capability, which cannot be provided adequately by tele-service alone);
- Long-term guarantees to ensure sustainable and economically predictable operation over 20 years, for example.

## Configuration of automated parking systems

As for any other parking system, the configuration of an automated parking system should, right from the start, involve a specialist planner with experience in designing automated parking systems. This is the only way to compare the advantages and disadvantages of all potentially suitable parking systems, both conventional and automated, and to find the best solution, as not every automated parking system is suited to every location. For optimum results, manufacturer-independent planning is required, meaning that developing a coherent overall concept takes precedence over simply choosing a suitable conveyance type and going from there. The solution that is finally implemented must be configured and optimized for the specific conditions of the respective location. Apart from technical and traffic planning issues, economic evaluation is also required. As such, by referring to generic features, the scope of this section includes a few guiding points, without laying claim to exhaustively covering all relevant aspects.

The installation of additional conveyance devices, empty spaces or transfer cabins that may be desired to enhance performance actually tend to cancel out the space-saving benefits offered by automated parking systems.

Figure 1: Automated parking system in Aarhus, public use, 1,000 parking spaces, shuttle-lift system and transfer cabin Photo: Lödige Industries


Figure 2: Entrance to Aarhus automated parking Photo: Lödige Industries

Figure 3: Automated parking system in Munich Karlstrasse, exterior view Photo: GIVT

Figure 4: Automated parking system in Munich Karlstrasse, transfer cabin Photo: GIVT

## Typical reference values

System-related logistical time periods typical for a parking shelf are given as follows: For each transfer cabin, a 2- to 2.5-minute rhythm can generally be assumed, depending on its access links and without claiming general applicability. Minimum vehicle retrieval periods stand at around 45 seconds. The maximum retrieval period in high-bay stacking systems of reputable manufacturers stands at around 3 to 3.5 minutes, while in pallet-shifting systems retrieval takes around 5 minutes. These time periods are quite acceptable compared to those in conventional car parks, where users have to walk to their vehicles and often lengthy maneuvering and driving processes are required. Inbound parking procedures are often shorter because there are fewer transfers. For the calculation of outbound and inbound parking performance, personal transfer cabin occupation times including possible waiting periods for the use of other conveyance devices and processes must additionally be considered.

## Examples

Automated car parks with more than 500 parking spaces are rare. As a rule, in Germany, for large parking facilities it has proven more cost-effective to fall back on conventional solutions. Moreover, it is strongly recommended to exclusively use system types that are based on the proven basic structures of experienced manufacturers. The largest automated parking system in Europe was recently planned in Aarhus, Denmark, and provides 1,000 parking spaces using a 'shuttle-lift' system (see *figure 1* and *figure 2*). More common are systems with up to 20 parking spaces on small building sites, as shown in *figure 3* and *figure 4*.

Automated parking systems fit into today's modern world, but their complex technical layout and processes require specific planning expertise. Moreover, original investment and operating costs per parking space are relatively high. The advantages of automated parking systems regarding the use of available floor space and building site space can only be meaningfully assessed when all relevant criteria (available cubage and ground area, number of parking spaces, vehicle dimensions, location of the entry and exit drives or of the transfer cabins, traffic-related and system-related logistical requirements, etc.) are considered. ■

## LITERATURE

[1] Forschungsgesellschaft für Straßen- und Verkehrswesen e.V.: EAR 05 – Recommendations for facilities for stationary traffic, Cologne, 2005

[2] Verein Deutscher Ingenieure: VDI 4466. Automated parking systems – Basic principles, Düsseldorf, 2001

**Ilja Irmscher**, Dr.-Ing. habil.
Managing Director,
GIVT Gesellschaft für Innovative VerkehrsTechnologien mbH
Planning services for parking,
Berlin (DE)
**irmscher@givt.de**


All photos: Delphi

# Automated driving – right across the USA

Driver assistance systems, Delphi long-distance drive, enabling technologies, radar, lidar sensors, V2X communication

In spring 2015, automotive supplier Delphi Automotive, a manufacturer of sensors, automotive electrical components, electronic control systems, active driver assistance systems and engine technology, demonstrated the power of modern automotive engineering. After their successful driving debut at the CES in Las Vegas, engineers lined up what would be the longest automated drive to date. In March, a modified Audi SQ5 left San Francisco on an almost completely automated journey from the West Coast to the East Coast of the USA.

Author: Thomas Aurich

Loaded with Delphi technology, the test vehicle covered around 5,000 km on the east-west drive, the longest journey ever completed by an automated vehicle in North America (*figure 1*). Sure, it was a demonstration trip, but it was also an opportunity to test and validate the systems and explore its possibilities by exposing the technology to real-life situations and circumstances that are hard to test in a closed experimental setup. During the journey, the engineers collected enormous amounts of data and established that the basic technologies for improving the active safety of cars are already available. The data obtained allow the design options to be expanded and improve the understanding of the complex technology.

### First test drives exceeded expectations

Even before the transcontinental journey, Delphi had been using the vehicle in Mountain View, California and the surrounding area, as well as during the CES in Las Vegas. There, the car had already been confronted with a number of traffic conditions such as city crossroads, pedestrian crossings, unexpected obstacles, vehicles turning across its path, and more (*figure 2*). On top of that came a range of different weather and road conditions. The vehicle overcame these potential problems with flying colors.

### Technical equipment in the demo vehicle

The prototype autonomous driving car was equipped with a whole range of different sensors, using cutting-edge technologies and features, some of which are already available on the market. These included, for example, collision avoidance systems, integrated radar and camera systems, a rear-end collision warning device and lane departure warning equipment. These specific features will not all necessarily appear on future series-produced versions, but the move from active driver assistance technologies to automated driving brings with it daunting technical challenges in many different areas in parallel. The aim therefore was to integrate the systems into the car in the best possible way, taking into account any automotive engineering issues.

*Radar, camera and lidar sensors*
Radar, camera and lidar sensors (LiDAR: Light Detection And Ranging) detect changes in the environment around the vehicle.

**Radar:** The vehicle uses a combination of six electronically scanning radar (ESR) units and four short-range radar (SRR) units. The ESRs specialize in long-distance sensor functions such as adaptive cruise control and cross-traffic detection. A forward-facing ESR is integrated behind a front license plate that is transparent to radar, while the front left and front right ESRs are located behind protective glass. The ESRs on the rear left and rear right are positioned near to the C-pillars, and one rear-facing ESR is integrated into the bumper. The SRRs are located behind cover plates at the four corners of the vehicle.

**Lidar:** In contrast to rotating lidar units that protrude from the car, as used on many other independent platforms, vehicles working with Delphi technologies have six lidars that are integrated into the outer shell of the vehicle. This approach makes 360-degree coverage possible while maintaining the vehicle's aesthetics. The lidars generate a high-resolution point cloud that contributes to general object recognition, particularly in busy urban environments. The forward-looking lidar is integrated into the radiator grille, while the front left and front right lidars are located behind protective glass, and the rear left and rear right lidars are positioned near to the C-pillars and one lidar directed to the rear is integrated into the bumper. Each lidar is coupled with an ESR to effectively merge radar and lidar data.

**Sensor fusion:** The perceptual system of Delphi's automated vehicles improves efficiency by combining data from various sensors. As radar, visual and lidar sensors each have specific strengths and weaknesses, fusing the sensor data makes it possible to obtain a more accurate picture of the driving environment with a more robust detection of vehicles, pedestrians and other objects.

**Radio-based V2X communication:** For automated driving, Delphi platforms use dedicated short-range communications (DSRC) to communicate with the infrastructure such as traffic light systems (V2I), with other vehicles (V2V) and even pedestrians (V2P). V2X communications provide redundancy, which is particularly useful in urban environments where there are a large number of traffic lights, vehicles and pedestrians.

Intelligent software algorithms ensure that the systems always make the right decisions even in the most complex driving situations – for example when filtering into motorway traffic, crossing an intersection, or overtaking a cyclist.

## Multi-domain controller and Ethernet - important components of automated driving

The automation of driving is one of the factors that cause the volume of data traffic in cars to soar. Increasing interconnectedness both inside and outside the vehicle requires new solutions for the architecture of electrical and electronic (E/E) systems. The heart of tomorrow's automated driving solutions will be the main driver assistance control unit, the multi-domain controller, which uses the latest high-performance processors. The multi-domain controller collects a whole range of sensor information from the vehicle's environment for central analysis before the results made available to the on-board assistance systems. The controller is thus the pivotal interface for all functions in automated driving. The design and architecture of the control unit are part of Delphi's innovative concept for the fast and secure processing of large volumes of data. Usually, the information is processed by various different control units that are all separate from each other.

Ethernet is going to be an important standard for both the vehicle's internal communications network and the connection systems. Thanks to its high bandwidth, it should eventually be able to replace bus protocols such as MOST and FlexRay, at least in part. Based on a study carried out in 2014 by ABI Research, an intelligence company focusing on the technology market, the use of network technologies in new vehicles will have risen still further by the end of this decade. A realistic scenario is that by 2024, the implementation of the Ethernet standard in new cars will take up almost 40 % of the connections.

## Different roads, different weather conditions

The automated drive from the West Coast to the East Coast of the United States – from San Francisco to New York – was the first

**BACKGROUND INFOMATION**

**The "Development Track" from Wuppertal to Silicon Valley**

The Delphi site in Silicon Valley was set up to further accelerate the development of the portfolio that covers products concerning safety, environmental protection and interconnectivity. The Valley offers not only the flexibility to extend cooperation with an increasing number of technology partners, but also direct access to a rich pool of talent. The Technology Center in Wuppertal, Germany, is one of the largest in the Delphi organization, specializing in the development of electronics, E/E architectures and system integration. Research and development activities in Germany and neighboring European countries ensure that technologies related to automated driving are being developed in line with the needs of European market.


Figure 1: Route of the Delphi coast-to-coast automated drive


Figure 2: Autonomous driving vehicle turning into traffic

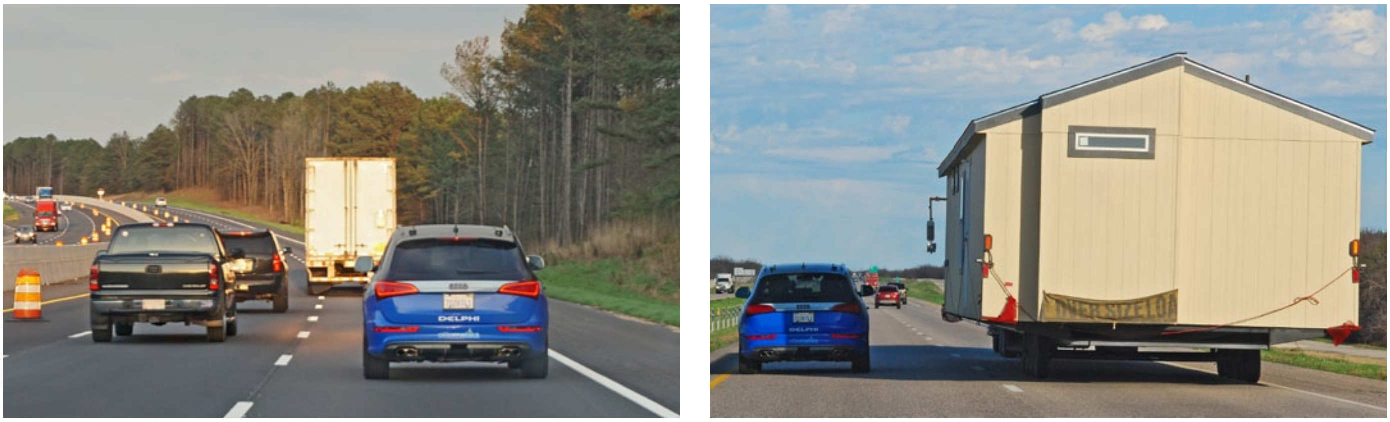


Figure 3: Autonomous driving vehicle in different situations on a highway

such trip to be undertaken by an automatically driven vehicle. The Delphi engineers used the trip to collect and evaluate the data and information that will aid the development of technologies for active safety, which is the fastest growing area in the automotive industry. The team collected nearly three terabytes of data – the equivalent of about one-third the amount of data stored in the Library of Congress in Washington.

The nine-day trip passed through nine US States and Washington D.C. On its route, the demonstration vehicle was exposed to diverse and challenging driving conditions: complex traffic situations, such as roundabouts, road works, bridges, tunnels, aggressive road users and different kinds of weather, but also to constantly changing road conditions, from bustling big cities to lonely cross-country roads (*figure 3*). The vehicle covered 99 % of the total distance of 3,400 mls (about 5,400 km) in fully automatic mode (*figure 4*).

Figure 4: Delphi car at the finish in New York

It showed that it could cope well with rain and snow, thanks to the combination of different systems that are active under different conditions. For example, on snow-covered roads, the radar takes over the task of the cameras, and V2V or V2X can detect broken-down vehicles even in conditions where the cameras only sees a field of white, and pass on the additional information to the vehicle systems. These products for active safety are already being used in vehicles and help steer the car safely through different traffic scenarios.

## The future

To gain an idea of the different parameters involved in automated driving, it is useful to study a relevant guideline, such as the NHTSA's five stages of automated driving.

- Level "zero" represents non-automated driving.
- Levels 1 and 2 are already on the market and include technologies such as radar, optical systems, adaptive cruise control and lane departure warning. The driver is still fully responsible, including monitoring the environment and controlling the vehicle.
- In Level 3, the driver may cede full control to the system in safety-critical situations and under certain traffic conditions. Although the driver can still intervene if necessary, he or she no longer has to pay attention to the road all the time.
- Levels 4 and 5 correspond to high levels of automation, where the car intervenes on its own if the driver does not respond to the situation. The vehicle can perform all safety-critical driving functions automatically and "keep its eyes on the road" throughout the journey.

The developers at Delphi are convinced that these innovative technologies have an important influence. Moreover, there are already a number of studies that attempt to describe the impact on society also in terms of numbers. There are four areas in which automated driving will improve our lives: safety, comfort, practicality and efficiency (labor productivity and fuel consumption).

Safety is the area where to most significant improvements are to be expected. Customers are increasingly asking for active safety and would prefer not to have to constantly concentrate on the road situation while driving. This is why people will probably be prepared to pay a price for additional benefits such as these. Automated driving will appear in vehicles step-by-step, and manufacturers will be upgrading their vehicles accordingly, depending on available technology and market demand. Higher acceptance by consumers and suitable legal frameworks will certainly continue to drive this demand. ■

**Thomas Aurich**, Dipl. Oec.,
Chief Information Officer, Delphi Deutschland GmbH, Wuppertal (DE)
**thomas.aurich@delphi.com**

**Rainer Denkelmann**, Dr.
Chief Engineer Global, Advanced Engineering, Body&Security, Delphi Deutschland GmbH, Wuppertal (DE)
**rainer.denkelmann@delphi.com**

**Serge Lambermont**, Ing. Physics
Director Automated Driving, Delphi Electronics & Safety, Delphi Automotive, Silicon Valley (USA)
**serge.lambermont@delphi.com**

# Smart-phone assisted travel assistance for passengers with reduced mobility

Public transport, passenger information, reduced mobility, accessibility, assistance application

Public transportation is a main factor for reliable mobility in urban and rural areas. Every user group and their specific requirements have to be considered during planning and realization of public transportation services. Hence public transport operators have to ensure a barrier-free public transportation service. Certainly this barrier-freeness still is not realized for every user group, due to the high complexity of public transportation systems. This article outlines an individual travel assistance application for smart phones which can be easily integrated into existing background systems of public transport operators.

Authors: Lars Schnieder, Werner Bischof

People wish to be independently mobile. Local public transport plays an important role in enabling everyone to fulfil his or her individual demand for mobility. At the same time, mobility is a prerequisite for social inclusion both in urban and rural areas. However, for people with disabilities as well as for people with reduced mobility barrier-free access to public transport is of great importance. Around the world, there are over one billion people with disabilities. In Germany, the figure is around 9.6 million, which is about one in eight of the population. Seamless accessibility covering the entire transport system requires structural works, vehicles as well as communication systems so that they can be used by all mobility-impaired persons without great difficulty and largely without the help of others. The project aim4it (accessible and inclusive mobility for all with individual travel assistance) is an example of a comprehensive information and communication system designed to significantly reduce currently existing barriers in public transport. This article introduces the underlying system architecture as well as the use cases supported by it.

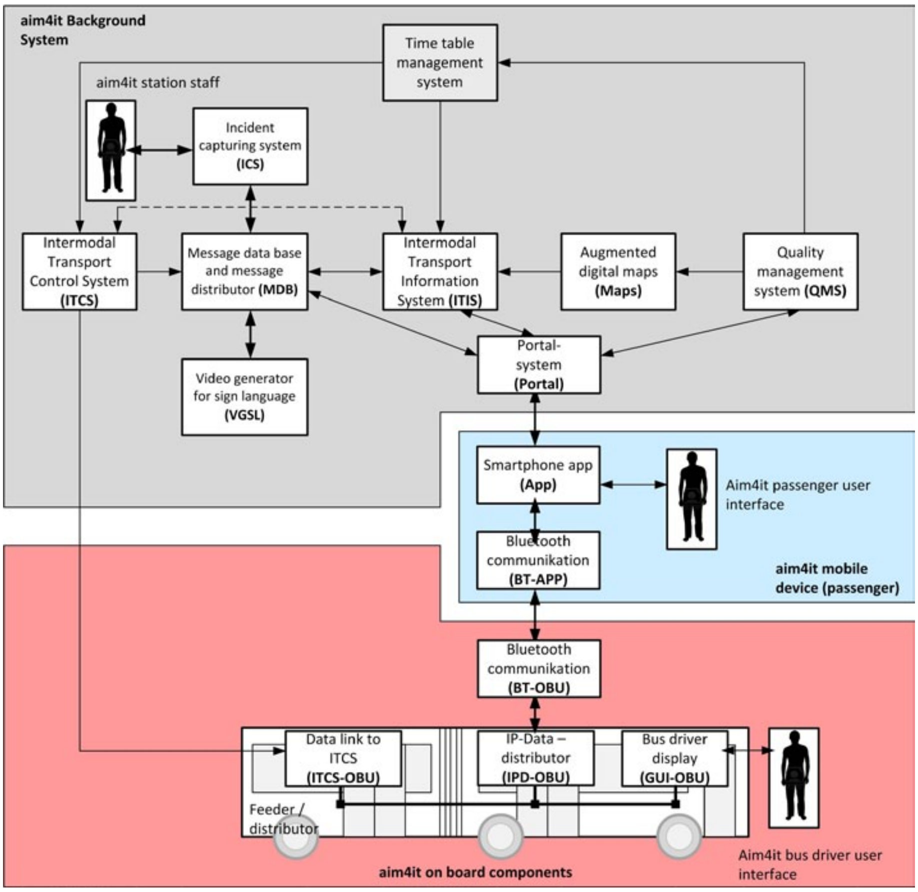



Figure 1: Overview of aim4it system architecture

## Overview of the Aim4it System architecture

The project aim4it integrates into the existing information and communication technology currently used by public transport operators. The aim4it system architecture consists of a background system, a smartphone application as well as a driver interface. The main system elements with the existing links between them will be explained in the following. *Figure 1* shows an overview of the aim4it system architecture.

The *Intermodal Transport Information System* (ITIS) provides travel information services for passengers. With the use of mobile devices passengers connect to the ITIS using standardized internet protocol-based communication (TRIAS, Travelers' Real-time Information and Advisory Standard). The TRIAS interface consists of a modular set of services where each service has a well described interface. These services can be consumed either directly by the travelers' mobile clients or by immediate systems which could provide additional services for its users [1]. With the ITIS passengers can plan their trip and receive further information while they are on their trip (e.g. available updates about their scheduled travel as well as necessary connections in between).

There is no direct connection between the passengers' mobile devices and the ITIS. A dedicated gateway (*Portal system*) is introduced to abstract from the specific mobile device used by the traveler. This layer of abstraction is required because there are many limitations for mobile devices with respect to energy consumption, connectivity and also the capabilities of the operating system. The *Portal system* can handle all these limitations. For example the gateway can use different Push-Services for the different smartphone operating systems [1].

The *Intermodal Transport Control System* (ITCS) transmits information about the current operational status of the public transport system to the ITIS. The ITCS has a bidirectional data-link to the vehicles (e.g. professional mobile radio or a public land mobile network) and receives all vehicles' current positions. Furthermore the ITCS supports decision making by the operator and broadcasts information to the vehicles. In the aim4it project vehicles receive requests for prolonged waiting times at interchange stations for connection protection as well as requests for staff assistance at specific stations.

By means of the *Incident Capturing System* (ICS) passengers can be informed about currently existing irregularities in the provision of public transport operations. The public transport operator can enter information about the nature of possible disruptions and/or modifications of public transport services. These messages can also be used in the ITIS for an automatic calculation of route updates that travelers receive with a push-update. With this information on hand, passengers can decide whether to wait or to take an alternative route. ICS support collection, management, and publishing of passenger information related to service irregularities in any form or medium [2]. This digital content can take the form of text, announcements or video files with messages being displayed in sign language using an avatar (see description of use cases below).

### Use cases supported by the aim4it system

With the architecture described above, several use cases will be supported. The use cases will be further explained below.


Figure 2: Bus driver display showing entry wish of wheel chair user at next station

*(Re-)Routing:* In order for a travel assistance application to effectively serve as a "guardian angel" guiding the passenger from start to destination the planning and execution of routes needs to be considered in detail. Initial planning of a route from start (street address or point of interest) to a destination is at least as important as calculating updates of routes once a previously defined route becomes impracticable (rerouting). Different events during a trip can trigger a rerouting.

(1) Real time passenger information (RTPI) reveals delays in the public transport network. Once a route is affected by a delayed vehicle a new route will be generated and sent to the respective passenger via a push-update.
(2) Incidents in the network (e.g. an accident) have an impact on available public transport services and require passengers to take an alternative route.
(3) The passenger is not at the right location at the right time and misses the vehicle.
(4) The passenger actively changes his plans and asks for an alternative. This can be a change or a cancellation of an existing route.

In case the passenger has "booked" additional service features with his initial route re-routing has an impact on other use cases supported by the aim4it travel assistance application, e.g. "request for staff assistance" and request for "connection protection". Input parameters for these use cases will be updated or requests will be cancelled.

*Request for connection protection:* There are only some of the wide range of possible trips in a public transportation network which are realized by direct connections. Often interchanges are required. To provide a dependable service for passengers transport, operators directly monitor connections. If needed, the connecting vehicle can wait for passengers of the feeding vehicle. With aim4it the connection protection request takes into account that passengers with reduced mobility or sensual restrictions need a longer transfer time between the vehicles. Based on this service the connection will be guaranteed and the passenger will be informed in time. The driver of the receiving vehicle will be informed about the prolonged waiting time at the demanded station. In addition connections can be cancelled if no longer required (e.g. due to rerouting) to avoid delays.

*Incident information (in sign language):* All passengers need to get access to detailed and reliable information regarding their trip. To provide such comprehensive information by the travel assistance application for sensory restricted passengers, this information has to be provided in an appropriate way. Barrier-free information includes the media supplying the information for the passenger. The aim4it project pays special attention to the demands of deaf and hearing-impaired passengers. This passenger group has difficulties in deciphering complex linguistic structures. Therefore the relevant information will be provided by sign language-based avatar videos [3].

*Request for staff assistance:* Staff assistance (e.g. by the driver) provides an easier usage of public transportation for passengers with reduced mobility or sensory restrictions. For trip assistance services the passenger must make a reservation via the aim4it travel assistance application. This has to be carried out prior to the trip. With the direct communication from the ITCS to the vehicle the request is displayed to the driver (see example of driver display in *figure 2*). The staff member awaits the passenger with mobility or sensory restrictions at the previously defined station and helps the passen-


Figure 3: Recognition of which line the approaching vehicle is assigned to with direct communication between smart phone and vehicle


Figure 4: Placement of entry wish with direct communication between smart phone and vehicle

ger to board the vehicle. At the designated station the staff member helps the passenger to alight from the vehicle.

*In-vehicle passenger information:* IP-based communication will be realized by introducing wireless communication between the aim4it smart phone application and the public transport vehicle by means of a Bluetooth 4.0 interface. Thereby waiting passengers can recognize which line the approaching vehicle is assigned to (see example in *figure 3*). Furthermore, additional information is sent from the vehicle to the smart phone application in the vicinity of the vehicle and on board. This contains information about the direction of travel, route and stop sequence, real-time information to catch connected services. Also deviations from the scheduled timetable can be sent. In addition to this the passengers with reduced mobility or sensory restrictions can place requests for staff assistance as shown in *figure 4*.

*Feedback function:* Public transport operators strive for continuous improvement of service quality of passenger transport. To do this the passengers have to be surveyed and actual performance continuously monitored [4]. With the aim4it feedback function passengers with sensory restrictions or reduced mobility will be involved in this improvement process. Service quality can be measured with the help of direct performance measurements derived from observing all transactions between the passengers' smart phone application and the central portal system. This information is combined with data from surveys embedded into the smart phone application. After specific events along the trip the passenger will receive a questionnaire where he/she is asked to rate satisfaction with a specific item. With the help of the assessed performances and opinions of the passengers the public transport operator can improve the performance level of service execution. The public transport operators can set up the right priorities for the adaptation of existing facilities and services to the requirements of passengers. In addition, gathered requirements can be taken into account for further design and planning of public transportation systems.

## Conclusion and Outlook

The project aim4it develops a travel assistance application which allows public transport operators to make a significant step towards providing public transport services which are inclusive and accessible.

The project aim4it develops additional functions and services which have not been part of a initial standardization project (IP-KOM-OEV) carried out under the initiative of the Association of German Public Transport Companies (VDV) [5]. The aim4it interface descriptions agreed on within the project consortium will result in work item proposals for subsequent standardization performed by VDV. VDV will continuously update its standards and will perform annual reviews of necessary changes to the IP-based communications interfaces to the on-board equipment and the real time passenger information system. Standardization of project results ensures that the aim4it travel assistance concept can be easily transferred to other regions. In February 2016 the prototype system will go into operations in the city of Vienna (Austria). In March 2016 the prototype system will start operations during the IT-Trans trade fair in the city of Karlsruhe (Germany). ■

## LITERATURE


[1] VDV-Schrift Nr. 430: Mobile Kundeninformation im ÖV - Systemarchitektur. Gesamtbearbeitung 01/2014, VDV (Verband Deutscher Verkehrsunternehmen)

[2] Daubertshäuser, K.; Redmann, M.; Gennaro, M.; Köhler, A.: Mehr Echtzeit für alle - Der Rhein-Main-Verkehrsverbund auf dem Weg zur verbundweiten Echtzeitinformation für Fahrgäste, Unternehmen und Aufgabenträger. In: Der Nahverkehr 7-8/2013, S. 56 ff.

[3] Schnieder, L.; Tschare, G.: Passenger information using a sign language avatar - Individual travel assistance for passengers with special needs in public transport. In: International Transportation 67 (2015) 1, p. 8 – 10.

[4] Bandelin, H.; Franke, T., Kruppa, R.; Wehrmann, A.; Weißer, D.: Einheitliche Plattform für ÖPNV-Kommunikation auf gutem Weg. In: Der Nahverkehr, 7+8/2012, S. 44.

[5] EN 13816: Transportation – Logistics and Services – Public Passenger Transport – Service Quality definition, targeting and measurement. Beuth Verlag (Berlin) 2002.


**Lars Schnieder**, Dr.-Ing.
Head of the Department for Intermodality and Public Transport, German Aerospace Center, Institute of Transportation Systems, Braunschweig (DE)
**lars.schnieder@dlr.de**

**Werner Bischof**, Dipl.-Ing.
FH Joanneum University of Applied Sciences, School of Electronics and Computer Engineering, Kapfenberg (AT)
**werner.bischof@fh-joanneum.at**

# Projects in a nutshell

## An overview of selected mobility research projects

## Efficient and functional – air-cooled drive unit

In the scope of the Fraunhofer System Research for E-Mobility (FSEM II) project, 16 different Fraunhofer institutes are jointly drafting solutions for the future of e-mobility. The three Fraunhofer institutes IISB, IFAM and LBF are pooling their expertise in the "Drivetrain/Chassis" cluster for an innovative air-cooled electrified drivetrain with adaptive chassis damper. This drivetrain consists of:

- air-cooled wheel hub motor,
- air-cooled drive inverter,
- multi-level DC-DC converter,
- adaptive chassis damper,
- rim designed for optimum cooling air flow.

The contributions of Fraunhofer LBF:

### Cooling-air-optimized rim

The influence of wheel disk design on air flow was studied to improve the wheel-side forced convection associated with air flow. In addition to the cooling effect and improved air flow, the decision criteria used were the result of the numerical structural durability calculation and the possible weight range. The rim was developed and designed according to the boundary condition for increased tire-sprung masses. The tests carried out in the wind tunnel showed that the wheel design has a significant impact on the cooling behavior and that the design with propeller spokes is beneficial in assisting wheel-side convection, depending on the design goal (*figure 1*).

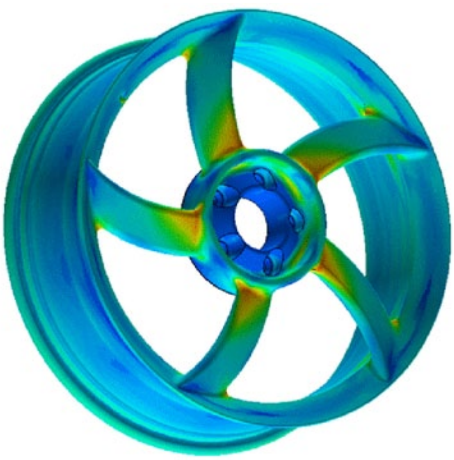


Figure 1: Cooling-air-optimized rim
Graphics: Fraunhofer LBF

For example, when using wheel hub motors, an approach aimed at optimum cooling air routing, low weight and a structurally robust design resulted in a 20-inch lightweight rim design with *cooling air routing improved by 5% and a weight of only 11.3 kg*.

### Adaptive chassis damper

A magneto-rheological damper featuring *innovative and energy-efficient magnetic field management* was developed to reduce the influence of the increased tire-sprung masses and to ensure maximum driving comfort. Magneto-rheological fluids are suspensions of ferromagnetic particles in a carrier fluid. The application of a magnetic field causes solid-state bridges to form, which lead to an increase in the transferable shear stress. The hybrid magneto-rheological damper utilizes this effect to adjust the damper stiffness in a vehicle: The stronger the magnetic field, the higher the damping force. When used in vehicles, this principle enables any necessary long-term adjustments to the damper stiffness by readjusting the permanent magnet. The coil current can be modified to achieve short-term, rapid adjustments of the damper setting (*figure 2*).

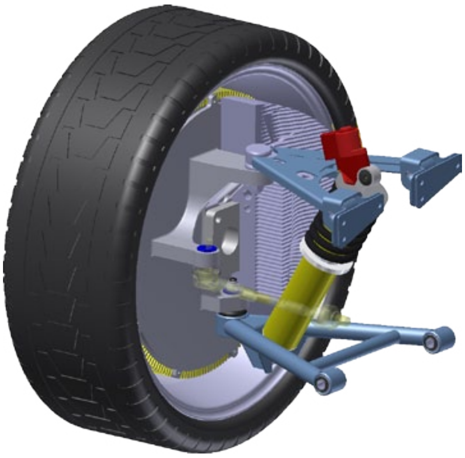


Figure 2: Adaptive chassis damper
Graphics: Fraunhofer LBF

### Testing concept for more efficient testing of structural durability

In vehicles with subsystems stressed by dynamic forces, the structural durability of these subsystems must first be tested on the test rig. With the multi-channel servo-hydraulic test rigs typical in this field, often considerable effort is required to define the control signals (drive files) before the test begins. The creation of drive files poses a particular challenge if adaptive components are present in the test specimen.

Rather than the usual mapping of system dynamics, a physical non-linear model of the test rig and the test specimen is created, which records the effects of the non-linear system dynamics and is also able to map the dynamic behavior of adaptive components. The following advantages emerged in numerical studies using the model of a three-channel servo-hydraulic test rig and a half-shaft subassembly with a non-linear adaptive damper:

- The iterative optimization of the drive file converges significantly faster than when using the previously usual linear transfer matrix. There is *considerable potential for saving time and costs* when preparing the test – examples illustrate a deviation *below 1% after 3 iterations* instead of a deviation of 3.6% after 10 iterations.
- No particular difficulties are encountered when *recording the continuously adjusting characteristics of adaptive components* with the result that they pose no problem for this form of drive-file generation.

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**Contact:** Dipl.-Ing. Eva-Maria Hirtz, Fraunhofer Institute for Structural Durability and System Reliability LBF, Darmstadt (DE);
mail: eva-maria.hirtz@lbf.fraunhofer.de

www. lbf.fraunhofer.de

# Portable fuel cell turns diesel into electric power

In the scope of a joint project, a group of research partners have developed an autonomous fuel cell system that is able to convert diesel into electrical energy silently – without the need for a motor or generator. Upon completion of the project, the system's technical maturity has been demonstrated in isolated operation of fuel cell stacks and electronic modules.

As a so-called Auxiliary Power Unit (APU), the fuel cell system for portable applications supplies electrical energy to caravans or boats. The APU delivers a maximum net power of 3 kWel for powering electrical devices such as the air conditioning system or the refrigerator. For efficient use, the diesel fuel already available on board needs to be transformed to hydrogen-rich fuel gas first. In a next step, the fuel cell converts the fuel gas to electric power.

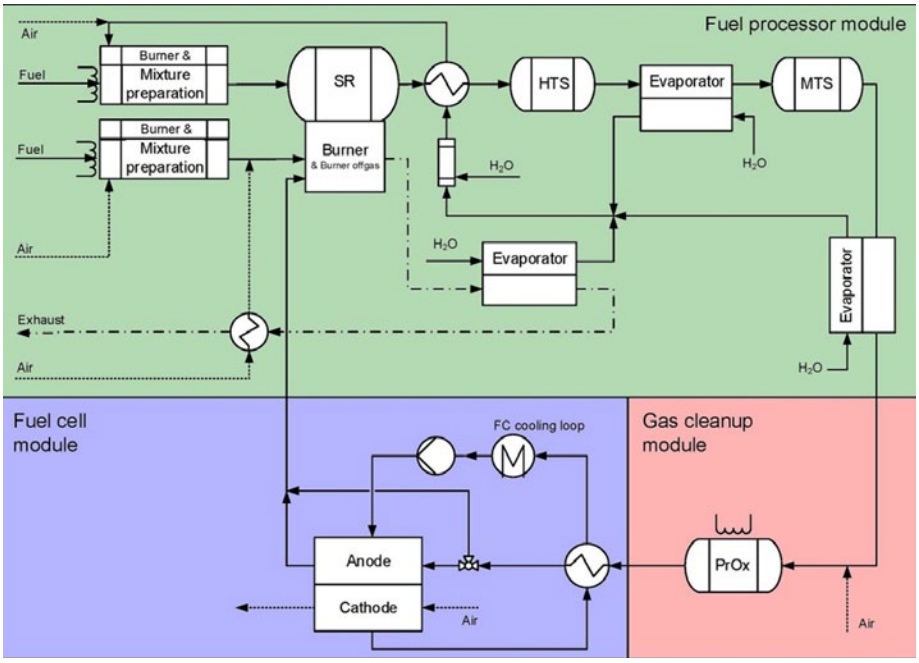


Figure 1: Basic design of the autonomously operating PEM fuel cell system for use as mobile APU
Illustration: OWI

## Development steps to a marketable power unit

The fuel cell system consists of a diesel and a water tank, as well as a hydrogen generator and fuel cell module, consisting of a low-temperature polymeric membrane fuel cell (NT-PEM) with 90 cells, a battery and the required power electronics. The developers' objective was to improve process control, reduce system complexity and evolve individual components as well as complete modules up to marketability. They optimized the system´s configuration to reduce complexity: Residual gas, i.e. gas that cannot be converted by the fuel cell, is not burned in a separate component anymore, but directly oxidized on the reformer part's side of combustion (*figure 1*).

An important step was to speed up the system start: For this purpose, the developers optimized the hydrogen generator module. The starting time of the fuel processor could be reduced to about half an hour through the use of a burner-side mixture controller, which can function either as an ignition burner or as a mixture controller with cold-flame technique. A new starting strategy was developed to reduce the whole system's starting time to less than 30 minutes. As soon as the reformer reaches the operating temperature required for oxidative steam reforming (OSR), fuel, water vapor and air are dosed into the reformer. The resulting temporary partial oxidation of the fuel gas initiates the generation of heat directly in the reformer component. The aim is to provide an earlier supply of reformate that will heat the water gas shift reactors reactively. At the same time, the fuel cell can reach the required operating temperature faster. With this procedure, the overall starting time (i.e. the time until the system is ready to start steam reforming) has been reduced to 20–25 minutes.

In March 2015, the design, construction and commissioning of the demonstrator were completed (*figure 2*). With the help of a representative test cycle, the system's functionality was successfully demonstrated in isolated operation of fuel cell stacks and electronic module. In this setup, the process worked without any connection to the laboratory infrastructure. All required fluid media were provided from tanks. The air dosage was ensured by blowers. The generated electrical energy was used for the internal system component's supply, for battery charging and for the connected load. For the demonstrator operation, building site spotlights rated at about 300 W each and an air conditioner drawing about 1 kW of electrical power were used as load. Several self-sufficient system starts could be realized with the battery.

Currently, the "Möwe" system is the only project that combines diesel steam reforming and a PEMFC polymer electrolyte fuel cell. Its advantages as compared to other technology combinations are:

- No additional fuel type and storage is needed because the system operates on diesel. Besides, diesel is commonly available and has a high energy density.
- Because of the steam reforming, hydrogen yield and hydrogen partial pressure are very high (up to 70 % dry concentration, to that no dilution with N2 is required).
- The NT-PEM fuel cell is ready for series production, has a long service life and only short starting times.

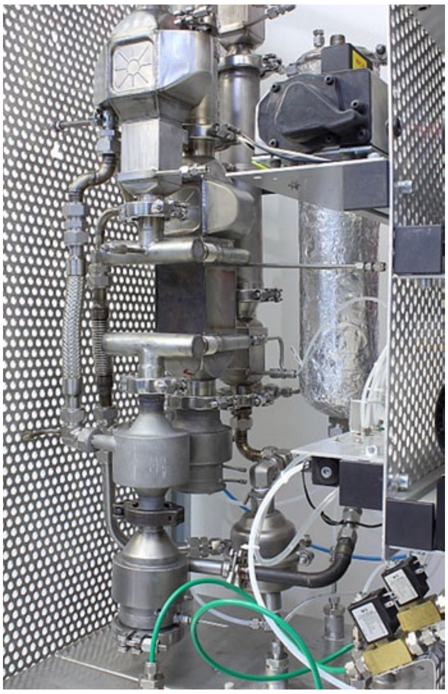

Figure 2: Hydrogen generator of the diesel-operated fuel cell system Photo: OWI

During the whole joint project, the developers had to face the challenge that the continuous operative stability of a low-temperature PEM depends on the reformer´s operating point. In a test run for the continuous operation of the reformer with low-sulfur domestic fuel oil, it was shown that a new regeneration strategy can largely prevent the typical degradation of the catalyst's reforming capacity caused by sulfur and soot.

### Replacement for conventional power generators

In the performance class of about 3 kWel, the only portable power generators currently available are powered by petrol or diesel motors. Their use at campsites for caravans or in port areas is strictly limited in order to prevent excessive noise and pollutant emissions. In contrast, the new fuel cell system works silently and generates hardly any emissions or vibrations. This is why the developers see the diesel fuel cell APU technology as a promising approach to power generation in several market sectors, for example caravans and yachts.

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**BACKGROUND INFORMATION**

**"Möwe" project partners**

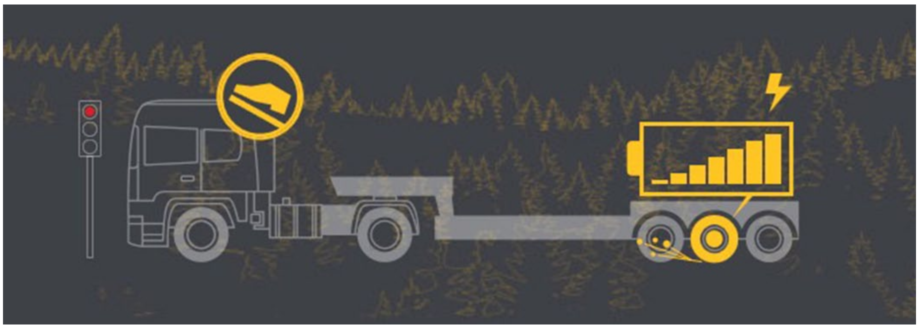
- Mahle Behr GmbH & Co. KG, Stuttgart
- Enasys GmbH, Berlin
- Inhouse Engineering GmbH, Berlin
- OWI Oel-Waerme-Institut GmbH, Herzogenrath

"Möwe" is the working title for the project funded by the Federal Ministry of Economic Affairs and Energy, following a decision of the German Bundestag.

**Contact:** OWI Oel-Waerme-Institut GmbH, Herzogenrath (DE); mail: m.ehring@owi-aachen.de

www.owi-aachen.de

# Kinetic Energy Recovery System for road haulage



Graphics: Adgero

Skeleton Technologies and Adgero SARL have developed the world's first Kinetic Energy Recovery System (KERS) for road freight vehicles. The unique hybrid system is designed to reduce fuel consumption and associated emissions by up to 25 %, and is optimised for intermodal road transport solutions.

The Adgero Hybrid System consists of a bank of high-power ultracapacitors working alongside an electrically-driven axle, which is mounted under the trailer. The technology is controlled by an intelligent management system that tracks driver input in order to automatically control the regenerative braking and acceleration boost.

Road haulage accounts for over a fifth of the EU's total $CO_2$ emissions, so fuel-efficient solutions are crucial. The technology is projected to reduce fuel consumption and associated $CO_2$ emissions by 15–25 %, depending on terrain and traffic profile. It will also pay for itself in as little as three years through reduced consumption alone, and where subsidies are available the payback can be even quicker. The product has also been designed to exceed the typical 10 year lifetime of the trailer itself.

Skeleton Technologies is the only ultracapacitor manufacturer to use a patented graphene material that allows better conductivity and a higher surface area, delivering twice the energy density and five times the power density of competitors' products.

Over the last year, Skeleton Technologies has worked with Adgero to adapt an 800 V ultracapacitor power module that is proving successful in the motorsport industry to meet the needs of road freight vehicles. The module consists of five 160 V units. With monitoring for each individual cell, the module is able to actively self-balance.

Adgero's system will be fully compatible with existing infrastructure and staff training programmes, and has been optimised for intermodal solutions. Any truck equipped with an Adgero monitor becomes a parallel electric hybrid when paired with an equipped trailer. If a truck without a monitor picks up a retrofitted trailer, the hybrid system will simply stay in standby mode.

### Successful tests

In recent months the system ran through rigorous testing procedures including vibration, shock and immersion testing. Road testing will begin in 2016 with Altrans, a French logistics company that is part of a trade organisation representing 11,000 vehicles across Europe. Adgero and Skeleton Technologies then plan to ramp up production, with the objective of producing 8000–10,000 units annually by 2020.

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**More information:**
Adgero, Strasbourg (FR), www.adgero.eu
Skeleton Technologies, Bautzen (DE), www.skeletontech.com

# A novel aircraft with many capabilities

Hybrid aircraft combining the best of an airship, plane, helicopter and hovercraft could provide major benefits in numerous applications. Scientists improved current concepts in a rigorous experimental and modelling campaign.

Designed to enable extremely short take-off and landing on all surfaces, such hybrid aircraft are well-suited to accessing remote areas without airports. Applications could include search-and-rescue missions, island hopping and tourism, and expanded business connections (*figure 1*).

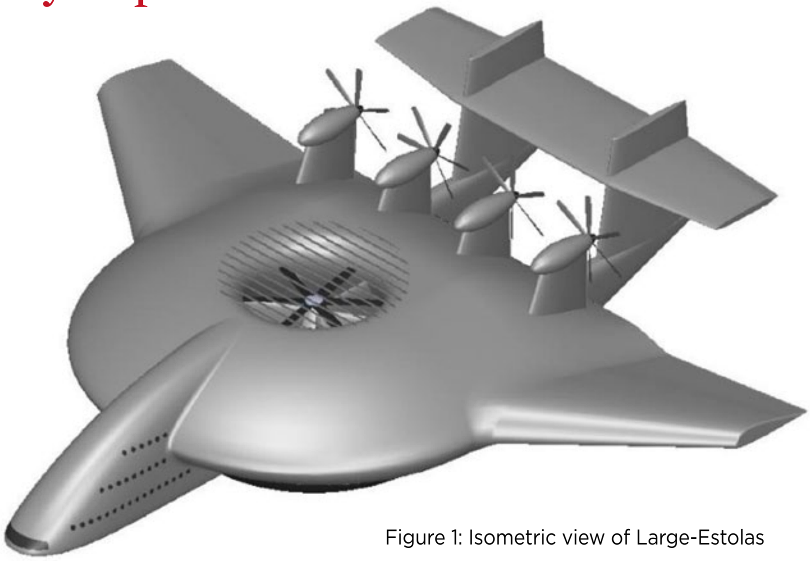

Figure 1: Isometric view of Large-Estolas

Building on a partner's previous experience and a working full-size prototype, scientists set out to test the theoretical solution to the low stability problem observed in certain situations. With EU support of the project Estolas, the team proposed an architecture akin to a mixed-type flying wing. The main part was a disk-shaped centreplane housing the helium and with a channel in its centre for a cargo cabin. On the edges were the pilot and passenger cabin, cantilevered wings and the tail. The combined take-off and landing gear were placed underneath.

Estolas set out to optimise the aerodynamic flanges to resolve stability issues for four different models accommodating small, medium, large and super-large payloads. Within the scope of the project, scientists also evaluated the performance of demonstrators in wind tunnel and remote-controlled flight tests and studied aspects related to runways, safety and certification.

Aerodynamic experiments on the Estolas hybrid aircraft provided important data on lift. In addition, the team evaluated performance with both currently available advanced engines as well as planned future engine concepts. The proposed propulsion system paves the way to pioneering flight control that enables vertical take-off and landing operations even for aircraft with heavy payloads. The team proposed an optimal architecture for a future all-electric Estolas in line with EU goals for the transport industry.

The Estolas concepts were superior to other aircraft in their capabilities for short take-off and landing as well as all-surface operation. However, to achieve additional clear advantages over traditional aircraft in other respects as well, the team identified specific technological areas for development.

Scientists have contributed comprehensive computer-aided design methodology and protocols for research and evaluation of hybrids. Together with models to predict performance criteria with minimal uncertainty, the tools will support knowledge-based advances in the hybrid aircraft model that has captured global attention.

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Download the final report here: http://cordis.europa.eu/docs/results/308/308968/final1-estolas-publishable-summary-final-report.pdf

**Project coordination:** Riga Technical University, Riga (LV), www.estolas.eu

# Galileo Online: GO!

## Highly accurate navigation receiver for rail applications

The objective of the project 'Galileo Online: GO!', which is scheduled to last until 2018, is the development of a highly accurate navigation receiver designed specifically for applications in rail transport. This receiver is to be connected seamlessly to a service platform for the provision of special services that will enable the receiver to be used directly in rail operation. The work focuses on ensuring powerful connectivity across the system as a whole, as well as on optimum accuracy, availability and robustness of the receiver's positioning solution.

Fraunhofer IIS, IMST GmbH, SCISYS GmbH, Vodafone and RWTH Aachen University are involved in the project. InnoZ GmbH supports the innovation process by contributing its socio-technical transfer method. 'Galileo Online: GO!' is a project carried out with the financial support of the German Ministry for Economic Affairs and Energy (BMWi).

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GALILEO ONLINE
GO!
DEUTSCHER GALILEO-EMPFÄNGER FÜR BAHN-ANWENDUNGEN

**Contact:** Valentin Jahn, Innoz GmbH, Berlin (DE); mail: valentin.jahn@innoz.de

www.innoz.de/e-gap0.html

# New high energy density automotive battery system


Figure 1: Kei Car electric vehicle prototype designed and assembled by IFEVS-Polimodel (Italy) Photo: Pietro Perlo, IFEVS

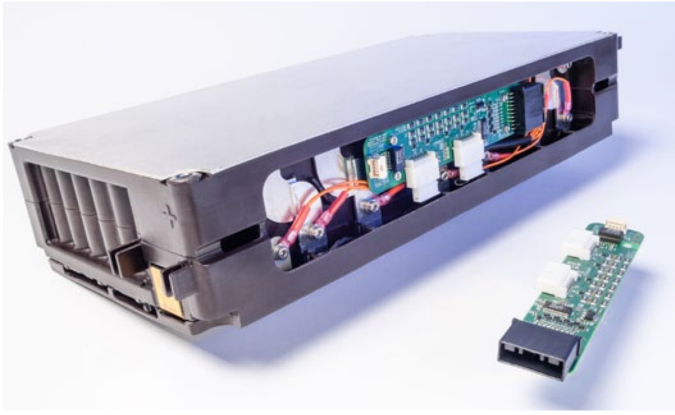

Figure 2: High energy density automotive battery module with cost-optimized battery monitoring electronics developed by Fraunhofer IISB with Dräxlmaier (Germany), Panasonic (Japan), and IFEVS (Italy) Source: Fraunhofer IISB

Fraunhofer IISB participated in the European AVTR project that has addressed the powertrain systems for light EVs. The IISB was responsible for a novel fully redundant battery system of an electric vehicle. An advanced battery management system was integrated, comprising control algorithms. The international AVTR project focused on a special EV that may fulfill the Japanese Kei Car specification. With the vehicle developed within the AVTR project, highest modularity, low costs and reduced complexity were implemented, as well as high-end Italian product design.

During the European AVTR project "Optimal Electrical Powertrain via Adaptable Voltage and Transmission Ratio" Fraunhofer IISB was responsible for the entire battery system of an electric vehicle (EV). In general, the Fraunhofer IISB Battery System Group focuses on innovative mechanical and thermal design of battery modules and systems including the related battery management system (BMS) with battery monitoring and the corresponding battery models. The project has addressed the development and the industrialization of complete powertrain systems for light electric vehicles. In contrast to already available EVs, the international project consortium focused on a special electric vehicle that may fulfill the Japanese Kei Car specification. The vehicle, developed by the Italian companies IFEVS and Polimodel, strictly follows four main objectives: low cost, modularity, producibility, and high-end Italian product design. The vehicle's total length is about 3 m, making it ideal for crowded inner-cities (*figure 1*).

Being part of the international consortium, Fraunhofer IISB was responsible for the novel fully redundant battery system. The main focus was on the battery system, its battery management system, and battery monitoring (*figure 2*).

The battery modules were designed in cooperation with the Dräxlmaier Group and manufactured by them. Highest modularity and independence of the battery cell manufacturer was achieved by using automotive grade 3 Ah cylindrical lithium-ion battery cells of type 18650 from an Asian battery manufacturer. Type 18650 battery cells are in highest mass production for years now, thus providing lowest costs, low manufacturing tolerances and are available from most premium cell manufacturers. The eight battery modules provide 12 kWh of energy to the 15 kW powertrain (30 kW peak power). The modules use a 20p7s cell configuration and have a weight of only 9.4 kg, thus providing a gravimetric energy density on battery module level (i.e., with electronics included) as high as 160 Wh/kg.

Furthermore, battery monitoring placed on battery modules followed the same objectives. Battery monitoring was optimized for lowest size and bill of materials. The PCB size could be reduced to only 47 cm$^2$, still providing best voltage measurement accuracy, temperature sensing and passive balancing. The small size could be realized by using a highly integrated state-of-the-art battery monitoring IC with highest voltage measurement accuracy. Panasonic developed and provided novel prototypes of MOSFETs including protective elements for passive battery cell balancing. By using these novel MOSFETs, the bill of materials can be drastically reduced, with positive effects on costs and reliability.

Finally, an advanced battery management system developed by Fraunhofer IISB and based on an Infineon 32 bit microcontroller running an automotive OSEK / Autosar operating system was adapted to the needs of the AVTR project and integrated into the battery system. The BMS comprises control algorithms (e.g. power contactor control), data communication via CAN bus, and advanced safety mechanisms for protecting the battery system. This BMS was integrated into both battery systems and configured to work as independent systems. Thanks to full redundancy the driver of the EV is able to check the state of each battery system on the dashboard and even driving with only one axle is possible at any time.

The shown concepts and prototypes prove the feasibility of a light electric vehicle with reduced complexity, reduced costs and improved modularity. This development may lead to affordable EVs, thus increasing the attractiveness of EVs for the mass market.

The final presentation of the vehicle prototype took place during the unique Parco Valentino car show in June 2015 in Turin, Italy. The AVTR project received funding from the European Union's Seventh Framework Program for research, technological development, and demonstration under grant agreement no 314128.

*red*

**Contact:** Vincent Lorentz, Fraunhofer Institute for Integrated Systems and Device Technology IISB, Erlangen (DE); mail: vincent.lorentz@iisb.fraunhofer.de

www.iisb.fraunhofer.de

# Natrans Arabia 2015

Preview: 25-27 October 2015 – The Gulf region's integrated and sustainable transport projects to be showcased in Abu Dhabi integrated transport event

NATRANS

Integrated transport strategy will be the focus of Natrans Arabia 2015, a first-of-its-kind event bringing together the Gulf region's transportation infrastructure with rail, road, and maritime projects, which according to Fleming Gulf research is worth an estimated 422 billion USD and will be completed within the next five years.

The conference-led exhibition is being held in partnership with the UAE Federal Transportation Authority – Land and Maritime and under the patronage of its Chairman, H.E. Dr. Abdulla Belhaif Al Nuaimi, who is also Minister of Public Works. The event will highlight the UAE's position within the region as a leader in transport infrastructure development. It is a discussion forum and showcase for proven, deployed schemes, pioneering research and development solutions that are intended to solve real-world problems that constitute critical regional imperatives.


Natrans Arabia takes place in the Abu Dhabi National Exhibition Center
Photo: Aravind Sivaraj/Wikipedia

Natrans Arabia consists of three separate conference streams, incorporating the region's established rail conference – the 6th Middle East Rail Opportunities Summit – on 25–27 October, plus two dedicated one-day conferences, addressing road issues on October 25th and maritime issues on October 26th.

During the 6th Middle East Rail Opportunities Summit, plans for network projects with a volume of nearly 200 billion USD will be presented, running across the Gulf coast from Kuwait through Saudi Arabia to the UAE and Oman, with branches linking Bahrain and Qatar. These projects will be completed before the end of the first quarter 2016. Abu Dhabi is spearheading the GCC rail network with its 40 billion AED (10.9 billion USD) Etihad Rail link project, which stretches for 1,200 kilometers, from Ghweifat on the Saudi border to south of Fujairah on the Omani border.

The Middle East Road Conference will examine the progress of the region's mega road project, which is set to grow at a rapid pace over the next five years, valued at an estimated 32 billion USD. The conference will also cover international traffic management (ITS), parking, road safety & maintenance and transport infrastructure projects.

The third streamed seminar, Middle East Maritime Conference, will take an in-depth look at the different investments in the maritime industry, which are expected to reach 66 billion USD in the next three years, with the UAE contributing 30-35 % of the Middle East's projected total investment, valued at 190 billion USD over the next three years.

With the expansion of regional shipping companies into world-class players, the global significance of the Middle East's ports and facilities is now more important than ever, and delegates will be presenting the latest industry developments. The conference will also feature international case studies about how operational and logistical challenges and complexities can be overcome.

Top-level transport delegations representing the UAE, for instance government bodies such as the Department of Transport, the Road Transport Authority, Etihad Rail, Abu Dhabi Ports, DP World and the Ministry of Public Works, will be attending the conferences. In addition, over 50 ministers and key government decision-makers will be attending this year's conference to discuss the potential partnership opportunities available right across the region.

Some of the key focus sessions include developing a competitive, sustainable and future-proof rail network for the GCC; effective interoperability among the new railway systems of the Middle East; integrated public transport for sustainable urban development; traffic management and surveillance; the role of automation in efficient port operations; the use of geo-spatial technologies in port security, plus a series of country-specific transport project updates.

Running alongside the conferences is an exhibition accommodating over 100 exhibiting companies. It is divided into four themed zones corresponding to the conference streams, plus an extra zone showcasing intelligent transport systems. The exhibition, which is likely to draw in excess of 2,500 trade visitors, has already attracted key support from the European Parking Association (EPA) and Mafex, the Spanish Railway Association, plus sponsors ESI Rail Ltd, Laborex and LGW. ■

**More information:**
www.natrans-arabia.com

# eCarTec Munich 2015

Preview: 20-22 October 2015 – Worldwide leading platform for Electric & Hybrid Mobility

Photo: eCarTec

In October 2015, eCarTec Munich – the world´s biggest B2B trade fair for electric & hybrid mobility – will be once more the industry's top international venue for electric and hybrid mobility. In the past six years, eCarTec Munich has developed into the international platform of reference for electric mobility.

With 463 international exhibitors and over 12,000 visitors from 56 countries last year eCarTec Munich has succeeded in expanding its standing as the international trade fair for electric and hybrid mobility, organized by the MunichExpo Veranstaltungs GmbH. The wide range of topics demonstrates that electric mobility means much more than only a transfer to electric vehicles. Its successful implementation also demands infrastructure, standardized charging systems, efficient battery modules, innovative material components and sustainable mobility concepts.

With its main topics "Electric Vehicles", "Energy & Infrastructure", "Energy Storage", "Powertrain & Electronics", "Mobility Concepts" and "eBikeTec" as well as its parallel fairs *Materialica– Lightweight Design for New Mobility and sMove360°* – Connected Car, the trade fair presents the entire range of electric and hybrid mobility. At eLive-Drive – the indoor and outdoor test track of the trade fair – visitors will get the opportunity to admire different electric vehicles or to even to enjoy driving them. The eCarTec Forum gives exhibitors the opportunity to present both their company and product innovations to an interested professional audience.

The entry to the forum is free of charge for all visitors of eCarTec Munich 2015. At the accompanying conference – the World Mobility Summit – numerous high-ranking experts will talk about current trends and innovative technologies in the focus areas Electric and Hybrid Mobility, Lightweight Design and Connected & Autonomous Driving. Another highlight at eCarTec Munich 2015 is the granting of the MATERIALICA Design + Technology Award and the eCarTec Award as Bavarian State Prize for Electric Mobility.

**More information:**
www.ecartec.com

# Cities for Mobility Congress

Preview: 19–21 June 2016 – 8th International congress on urban mobility in Stuttgart (DE)

The importance of cities as living space is growing. Cities are the engine of economic and social development. And they are places where the ecological and social challenges of the 21st century are particularly pronounced. Two of these challenges are the increase in mobility and the accessibility of our cities.

The global Cities for Mobility network is committed to finding common ways towards creating sustainable mobility systems that are environmentally friendly, economy-focused and accessible to all. More than 600 members in 85 countries are moving together for better mobility. The biennial Cities for Mobility World Congress serves as a forum for the exchange of knowledge between municipal transport experts, scientists and entrepreneurs. It is also a forum for presenting innovative solutions and initiatives and for making contact with potential project partners. The Municipality of Stuttgart announces the 8th International Cities for Mobility Congress, which will take place at Stuttgart City Hall. By the end of 2015, the Cities for Mobility Coordination Office will release further information on the event (main topics and draft program) via the dedicated website. ■

**More information:**
www.cities-for-mobility.net
www.cities-for-mobility.org

# World Efficiency Congress

Preview: 13–15 October 2015 – The first efficiency meeting in Paris

World Efficiency is the first biennial event for policy makers and businesses looking for resource and climate solutions. It will run from 13–15 October 2015 in the Porte de Versailles exhibition center in Paris, France.

The new event was born out of the desire of the organizers of Pollutec to create a meeting space for all those involved in the development of solutions that serve the interests of both the planet and businesses. Many of these solutions can easily be adapted and applied to other sectors. The aim is to bring the instigators and the players together in one place. Topics include for instance 'alternative' transportation: Solutions for "transporting differently" allow manufacturers, component suppliers and other specialists to develop highly fuel-efficient vehicles and drives, human-powered mobility systems; new types of communal transport, shared approaches to limiting the impact of personal mobility and the transport of goods, and much more.

The World Efficiency Show is complemented by a congress program revolving around innovative cities and regions. ■

**More information:**
www.world-efficiency.com/GB.htm

# ITA Awards 2015 – Hagerbach Underground Conference and Exhibition

Preview: 19 November 2015 – One-day conference and exhibition featuring more than 110 projects in 9 categories

On November 19th in Hagerbach, Switzerland, the international tunnelling and underground space community will get to discover the most outstanding and innovative infrastructure projects nominated for the ITA Tunnelling Awards 2015. Up to now, more than 110 projects from all over the world, carried out between January 2013 and February 2015, have been submitted to the jury consisting of 17 experts and chaired by Søren Degn Eskesen, President of ITA.

The submitted projects were examined and assessed by the jury from August to September. The nominees will present their projects during the one-day conference organized at the Hagerbach Underground Conference and Exhibition Center – a perfect occasion for attendees to get an updated overview of tunnelling activities around the world. The names of the winners in each category will be unveiled during the banquet on the same evening.

The high interest in the event reveals a solid need for contracting authorities, project managers and young engineers to receive more recognition at the international scale. Besides, the ITA initiative is a vital tool for encouraging the best practice sharing among tunnel professionals. Also, the awards play an important role in serving the public interest, because they help identify the most sustainable innovations when it comes to facing urban and climatic challenges. ■

**More information:**
https://awards.ita-aites.org

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### Publishing house
DVV Media Group GmbH
P.O. Box 10 16 09, D-20010 Hamburg
Nordkanalstraße 36, D-20097 Hamburg
Phone +49 40 23714-01
**Managing Director**
Martin Weber
**Publishing Director**
Detlev K. Suchanek
Phone +49 40 23714 227 |
detlev.suchanek@dvvmedia.com

### Editorial office
**Managing Editor**
Eberhard Buhl, M. A.
Phone +49 40 23714-223 | Fax: +49 40 23714-205
eberhard.buhl@dvvmedia.com
**Revision**
Dr. Barbara Gutermann

### Advertising
**Advertising Director**
Tilman Kummer
**Advertising Manager**
Silke Härtel (responsible)
+49 40 23714-227 | silke.härtel@dvvmedia.com
**Advertising Sales**
Tim Feindt
+49 40 23714-220 | tim.feindt@dvvmedia.com
**Advertising Technology**
Patrick Schröter
+49 40 23714-127 | patrick.schroeter@dvvmedia.com
For advertisement prices, please see price list no. 52 of 01 Jan. 2015

### Sales
**Marketing & Sales Director**
Markus Kukuk
+49 40 23714-291 | markus.kukuk@dvvmedia.com
**Licensing Digital/Print**
Oliver Brandt
+49 8191 3055039 | oliver.brandt@dvvmedia.com
**Reader's/Subscriber's Service**
Phone +49 40 23714-260 | Fax +49 40 23714-243
kundenservice@dvvmedia.com

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Sunny Manhattan skyline at East River
Photo: ClipDealer



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# Editorial Board



# Editorial Advisory Board

**Dear Readers,**

When we decided over a year ago to publish an English-language transportation journal and make it available for download worldwide, the first year's issues were intended as a trial balloon. A successful one: The May edition met with invariably positive response from readers and authors from municipalities, companies and scientific institutions alike. We truly appreciate your feedback and thank you for encouraging us to continue our project.
*International Transportation* 1/2016 will be published on 12 May 2016 and focus on the following topics:
**Green and smart: Sustainable transport – digital mobility**
These topics suggest themselves because the mobility landscape keeps changing at a breathtaking pace across the globe.
New services drive the trend towards a multi-modal mobility system that is desirable from both the ecological and the economic point of view. The digitalization of our entire living environment is picking up speed to an extent that was unthinkable just a few years ago. This explains why our authors are chiefly investigating innovative technical and administrative possibilities for providing access to mobility, creating and upgrading infrastructure systems, and ensuring data security and process safety.
Your suggestions as a reader are also always welcome: Just send me an e-mail to *eberhard.buhl@dvvmedia.com* and let me know about the topics and projects that you are especially interested in. I am looking forward to hearing from you.

Sincerely

Eberhard Buhl, Managing Editor

## CALENDAR OF EVENTS
01 October 2015 to 29 April 2016

**01–02 Oct 2015**
Rome (IT)
**URBE – URban freight and BEhavior change**
Organization: Department of Political Sciences and Centre for Research on the Economics of Institutions, University of Roma Tre
Info: http://host.uniroma3.it/eventi/urbe

**05-09 Oct 2015**
Bordeaux (FR)
**22nd ITS World Congress**
Towards Intelligent Mobility – Better Use of Space
Organization: Topos Aquitaine
www.itsworldcongress.com

**19–21 Oct 2015**
Abu Dhabi (AE)
**NATRANS Arabia**
Exhibition with 6th Annual Middle East Rail Opportunities Summit
Organization: Fleming Gulf Exhibitions
Contact: Kristina Schrammova, Tel: +421 257 272 144, kristina.schrammova@fleminggulf.com
www.natrans-arabia.com

**20–22 Oct 2015**
Munich (DE)
**eCarTec Munich 2015**
7th International Trade Fair for Electric & Hybrid Mobility
Organization: MunichExpo Veranstaltungs GmbH
Contact: Edyta Szwec-Mikicz
Tel.: +49 (89) 32 29 91-23
edyta.mikicz@munichexpo.de
info@munichexpo.de
www.ecartec.com

**20–23 Oct 2015**
Prague (CZ)
**2015 IAIN World Congress**
World Congress of the International Association of Institutes of Navigation
Organization: Guarant International
iain2015@guarant.cz
www.iain2015.org

**11–13 Nov 2015**
Dallas (USA)
**Go Mobile 2015**
Mobile IT solutions conference
Organization: Compass Intelligence Analytics and Consulting, San Antonio/Tx (USA)
Contact: gomobile@compassintelligence.com
www.gomobileconference.com

**29 Feb – 01 Mar 2016**
Essen (DE)
**4. Railway Forum**
Info: IPM GmbH
t.s@ipm-scm.com
www.railwayforumberlin.de

**15–17 Mar 2016**
Cologne (DE)
**Passenger Terminal Expo 2016**
International Airport Conference
Organization: UKIP Media & Events
Tel.: +44 (0) 1306 743744
andrzej.smith@ukipme.com
http://www.passengerterminal-expo.com

**05–08 Apr 2016**
Amsterdam (NL)
**Intertraffic Amsterdam**
Organization: RAI Amsterdam Exhibitions
Tel.: +31 (0)20 549 12 12
Contact: registration@rai.nl
www.intertraffic.com

**25–29 Apr 2016**
Hanover (DE)
**Hannover Messe**
Organization: Deutsche Messe
Tel.: +49 511 89-0
www.hannovermesse.d

For information on additional events go to
www.internationalesverkehrswesen.de,
www.eurailpress.de, www.schiffundhafen.de, www.dvz.de