New vehicle concepts for future business models.

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Rapid socio-economic changes and new business models demand for new vehicle concepts

Today there are already approximately 950 million passenger cars in use worldwide, tendency rising. This results in severe traffic problems: traffic jams, parking space problems, and extreme air pollution. Because urban areas are especially affected, cities around the world react with action plans. “Low emission zones”, “urban road tolls”, or even the total ban of specific vehicle types are being established to keep private, but also commercial vehicles out of the city centers[1]. The “Roadmap Towards a single European Transport Area” by the European Commission presents a strategy to alter the EU’s transport system with specific attention to the issues in urban traffic: the greenhouse gas emissions from transport shall by reduced by 60% with respect to 1990 and there shall by no more conventionally-fueled cars in cities by 2050 [1]. In line with this, Germany also adopted its own climate protection plan in 2016, which aims to be greenhouse gas neutral by 2050 [2]. An important step in this direction is to emit about 40% less greenhouse gases by 2030 than in 1990. This is to be achieved through specific measures such as increased expansion of public transport, promotion of alternative drive systems, or sector coupling. Figure 1 shows the current development of greenhouse gas emissions in various sectors in Germany. In the transport sector, passenger cars and motorized two-wheeled vehicles account for about three quarters of total transport performance. In freight transport, trucks are responsible for ca. 75% of the transport performance. The increased volume of traffic between 1990 and 2014 is the reason why the emission of greenhouse gases remained almost constant despite better vehicle efficiency. In order to achieve the targets, further measures must be taken in addition to increased vehicle efficiency technologies. Besides climate protection, trends such as demographic change, urbanization, and individualization towards a single-society demand for further developments in mobility systems.

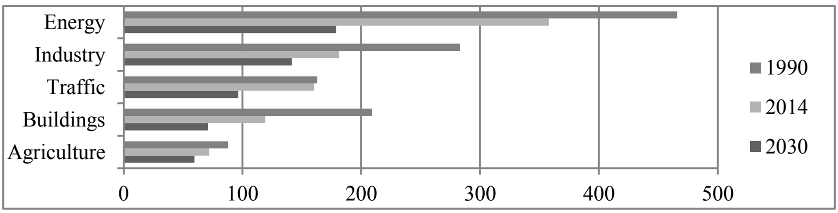


Figure 1: Greenhouse gas emissions (in millions of tons of CO_2 equivalent) in various sectors in Germany; incl. target definition for 2030 (own visualization, based on [2]).

[1] See e.g. “c40.org” and “urbanaccessregulations.eu” for an overview (accessed: 02.01.2019).

While prior developments focused primarily on the electrification of the powertrain of "conventional" vehicles, the interaction of the technology trends electrification, autonomous driving, and connectivity enable completely new, disruptive, vehicle concepts. The conventional car design, which existed for the last 130 years, is not inevitable anymore. Together with changing vehicle concepts, new business models come along: the sharing-approach aims to utilize equipment as efficient as possible by consuming them collaboratively. The digitalization allows for new business models like sharing single rides or cars, e.g. Uber or Car2Go. With the introduction of autonomous driving, the high costs for drivers are eliminated, making further business models attractive. Individual mobility changes from a possessing model to a service: "Mobility-as-a-Service" (MaaS) or "pay-per-use". A societal rethinking towards MaaS has the potential to improve current traffic issues sustainably.

These developments enable disruptive solutions which support the necessary transition to environmental friendly holistic mobility solutions. Multimodal door-to-door transportation is a key element in this process. Particularly in the commercial urban transportation sector, companies like parcel services, public transport operators, or truckage companies are looking for new concepts, such as urban logistic hubs as trans-shipment centers or concepts with freight bicycles.

In passenger transport, motorized individual transport (MIT) dominates for almost all purposes (Figure 2). In recent years, the absolute number of trips covered by MIT has continued to increase [3]. Together with the growing urbanization rate and the contradicting trend to urban access restrictions, this demands for new transportation concepts, e.g. by new incentivizing ways for public transport. Figure 3 illustrates the development of urban commercial traffic. The CEP market is growing enormously (in Germany: by 96% from 2000 to 2017 [4]). By internal analyses of [5], it could be derived that that there are only minor differences in mileage and payloads between the considered sectors. This speaks in favor of a vehicle concept which can carry application-optimized transportation units on a standardized platform (modular vehicle concepts). A similar result was achieved in the context of the "Urban Mobility" project at the German Aerospace Center: In the urban area very different vehicles are in use. This can be explained by the fact that very different users and people with very different mobility requirements live in cities and thus different vehicles with different properties are used. From this context, it can be seen that either vehicles designed for specific requirements could be used in the future (e.g. use-case optimized sharing vehicles). Alternatively, flexible (modular) and customizable vehicles could be conceivable as a disruptive variant. In the project, various user groups (personas) were derived on the basis of a stakeholder analysis. Apart from the "urban bike lovers", all other personas requested a vehicle with adaptable dimensions [6].

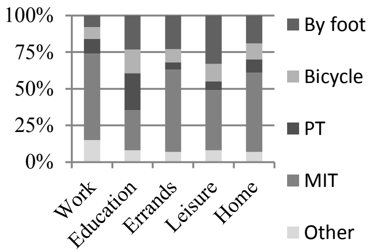


Figure 2: Modal-split by driving purpose in Germany (2017)[2].

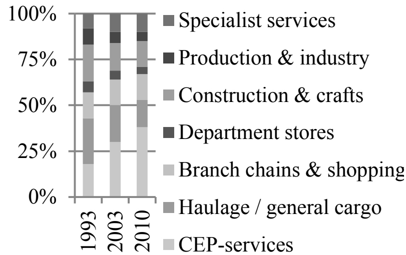


Figure 3: Share of commercial vehicle trips by sector in urban areas[3].

Novel "vehicle" concepts – Benchmark of existing concepts and business models

Several classical automotive as well as non-automotive players present unconventional vehicle concepts to address the issues of the previous chapter. Not all of them are ground-based, some try to lift everyday mass traffic into the air, while others propose new tube-based solutions. In the following some published concepts will be introduced, including their business strategy (if available). The following brief overview shall give an impression how many visionary ideas there are in this field.

Airborne and tube-based vehicle concepts

By far the most concepts have been introduced in the field of road vehicles. However, there are some disruptive concepts for air- and tube-based-traffic as well (Figure 4). There have been introduced several "VTOL" aircraft concepts for urban traffic lately: for instance, the "2X" by Volocopter, Lilium, or "Elevate" by Uber. They all follow a similar business model: the VTOL (vertical take-off and landing) aircraft is used as a Peoplemover to carry people in crowded mega cities faster from A to B. Typically they intend a Park&Ride approach for commuters, which shall cost less than a taxi today [7], [8].

[2] Own visualization; Data from [3]; PT: Public Transport; MIT: Motorized Individual Transport

[3] Own visualization; Data from internal analyses; CEP: Courier, Express, Parcel

Companies like Doppelmayr or Leitner implement a conventional technology in a new environment: they install aerial cableways in urban regions. This way, the ground-bound traffic is lift up in the air, relieving traffic jams, offering Park & Ride, bridging inaccessible terrain, and creating new connections for multimodal transportation system. They claim to be 2,000 times as efficient as individual owned cars and 100 times as efficient as busses (based on the capability to carry 10,000 people per hour). Their key selling points are i.a. short construction times, nearly silent operation, and high efficiency [7].

Figure 4: Airborne and tube-based concepts. L.t.r.: Volocopter 2X, Lilium, Doppelmayr, Hyperloop One [7]

Another disruptive transportation concept is the Hyperloop: Like in a letter shoot, capsules move through an (almost) evacuated tube at an intended speed of 960 km/h. There are several companies working on the Hyperloop, such as the "Hyperloop One". The tube could be installed above ground or below ground [7]. With the foundation of “The Boring Company”, Elon Musk wants to lower traffic underground. The Hyperloop shall work in the tubes as well. For the beginning, however, he has in mind that electrified Peoplemover drive at up to 240 km/h in these underground tubes [9].

Ground-level based vehicle concepts

For road vehicles a modular approach has become popular within recent vehicle concepts. Their common goal is to provide tailored vehicles for specific applications, not the conventional one-fits-all approach. This way a purpose- rather than a conversion-design approach can be effectively implemented. 1) The modular-production approach separates the conventional vehicle in individual components, which can be assembled to use-case optimized designs. 2) The on-the-road (otr) modular approach pursues a strategy that focuses on only two modules: a standardized drive module and a purpose-optimized transportation unit which can be changed dynamically during operation. All new ground vehicle concepts have in common that they are designed for highly autonomous and connected functions as well as all-electric propulsion.

Modular ex-factory vehicle concepts

The modular-production approach enables car manufacturers to easily produce a high variation of application-optimized vehicle derivatives by using a lot of identical components, and thus i.a. reducing the production and development costs. When the modularization rate is very high, only two components have to be assembled anymore to get a unique vehicle: platforms with the driving functions and transportation units, which are designed for specific purposes. These two components get "married" at the end of the production. However, the vehicles are fixed when leaving the factory, i.e. a dynamic change of transportation units on the road is not possible [10], [11]. Companies such as Open Motors ("EDIT"), Toyota (ePalette), or Renault (EZ-Pro) have introduced ex-factory modular vehicle concepts lately. These manufacturers follow a "Mobility as a Service" (MaaS) approach. They provide the platform, while partners such as Amazon or Pizza Hut get closely involved during the design process of the "hats". The manufacturers maintain and replace damaged parts during the lifetime of the application-optimized vehicle. Part of the MaaS strategy is that the partners can always access and analyze the vehicles' data [7].

The UNICARagil project initiated by several German universities also pursues ex-factory-different derivatives that are based on scalable drive platform and varying usage units. Accordingly, there will be variants for taxis, shuttles, private use and parcel services. Besides the modularization, the research's focus is i.a. on the development of an innovative electronic architecture, addressing e.g. updatability, service-based software architecture or fail-safe protection for different applications. [12].

A very popular application for modular vehicles is the use as **Peoplemover**. Many companies and research institutes see on-demand Peoplemover as a solution to cope with the increasing mobility demands in cities. Whereas modular vehicle concepts mostly inherit a shuttle-solution besides solutions for multiple other applications, there are others like Local Motors that specialize on Peoplemover only. Their vehicle concept "Olli" is perfectly suited as a shuttle to transport people on-demand and shall support local public transport in the future [7]. Other concepts are shown in Figure 5. The concepts all look quite similar as they are each optimized for transporting people.

Figure 5: People mover. L.t.r.: Local Motors Olli, EasyMile EZ10, Continental CUbE, Bosch Shuttle, Navya, Paravan CLOUi, VW Sedric [7].

On-the-road modular vehicle concepts

The former vehicle concepts have been modular in regard, that they are assembled on top of the same modular platform. On-the-road (otr) modular vehicles inhabit another kind of modularization. They are split into a drive module ("driveboard") and a transportation module ("capsule"). In a conventional car this would mean the chassis and the cabin. The autonomous driveboard can pick up different capsules on-the-road according to the upcoming transportation task. The change-system is the key function of these concepts. The concept only makes sense for autonomous driveboards. In this case, round-the-clock operation is possible and high personnel costs are eliminated. The capsules are optimized for specific purposes, for instance for people transport, parcel delivery, etc. Possible capsule designs are similar to the ones introduced by the business models in the previous chapter. This dynamic otr modularization allows for an efficient and flexible use of the costly driveboards.

A well-published otr modular vehicle concept is the "Snap" from Rinspeed, which's lifting system is integrated into the corners of the capsule (Figure 6), allowing the driveboard (formed like a skateboard) to drive under the capsule which then lowers down. Further, they showed a complementary concept, the Rinspeed "microSNAP" at the CES 2019. This is basically a smaller version of the Snap, differing primarily in the lifting system to change the capsules. However, this concept needs robots to lift the capsules from the driveboards (Figure 6). Together with the microSNAP, Rinspeed announced that their business model works with swarm-intelligence to optimize the logistics. The interior, depending highly on the application, shall be designed by the business customers [7].

Continental's otr modular concept "BEE" shall incorporate swarm intelligence as well, hence, the name bee. The ex-factory modular vehicle concept CUbE is part of the vehicle swarm as well. The BEE is primarily intended to be an urban people-mover, but capsules for other applications are also part of the system. However, BEE misses a continuous concept for the modularization [7].

Figure 6: otr modular vehicle concepts. L.t.r.: Rinspeed (Snap and microSNAP), Mercedes-Benz (Vision Urbanetic), Continental (BEE), Airbus (Pop.Up Next) [7].

Mercedes-Benz demonstrated their "Vision Urbanetic" concept in 2018. Like the Snap, it shall be modular on the road; however, it is not clear how the automated change of capsules works exactly. The way they extend the gauge is questionable as it might lead to abrasion. Until now, the Vision Urbanetic integrates a "delivery" capsule as well as one for passenger transport [7].

The concept “Pop.Up Next” which has been presented by the collaboration of Airbus, Audi, and Italdesign, combines technologies of aircrafts as well as ground-level vehicles in a dynamic otr modularization. It consists of a driveboard and separated capsules, complemented by an autonomous and electric drone with an interface to pick up the capsules. This way the Pop.Up Next is both, a ground vehicle as well as an airborne shuttle – until now, it is set up for on-demand people transportation only. The drone replaces the otherwise necessary lifting system as it can vertically take-off and land. It receives its energy through a charging chain: the driveboard is charged at the ground, forwards the energy to the capsule which again charges the drone when connected. The consortium envisions the capsule to be integrated in further transportation systems like trains for a multimodal transportation system [7].

Next Generation Car: Urban Modular Vehicle

The cross-institute meta-project "Next Generation Car" (NGC) at the Germany Aerospace Center (DLR) combines the competencies of various institutes to develop innovative vehicle concepts that offer answers to changing mobility needs and user requirements. In addition to the vehicle structure and concept, energy management, powertrain, chassis, and vehicle intelligence are also taken into account for developing eligible vehicle solutions. This results in alternative powered (zero-emission) and automated (zero-accident) solutions that can be integrated into the mobility system in a cost-effective, safe, and holistic way. Three vehicle concepts have been developed: The NGC Safe Light Regional Vehicle (SLRV), a cost-effective and very safe vehicle in the L7e class, the NGC Interurban Vehicle (IUV), a comfortable vehicle for long distances, and the NGC Urban Modular Vehicle (UMV) (Figure 7). The **NGC UMV, a modular ex-factory vehicle concept**, considers trends of increasing urbanization, modularization, electrification, and the introduction of high levels of automation. The UMV illustrates the versatility of conventional individually driven road vehicles to completely autonomous road vehicle on a platform. The NGC-UMV offers this through an intelligent modular platform concept in the body structure, in the powertrain and the different levels of automation levels. The flexibility of the platform offers the possibility to realize a wide variety of electric vehicle derivatives for people and goods: (a) the UMV Basic, 2+2 seater with a length of 3.7 m; (b) the UMV Long, 2+2 seater with 4.1 m and a larger trunk; (c) the UMV 2+Cargo, a small delivery van; (d) a fully autonomous UMV Peoplemover as 2+2 seater; (e) the UMV Cargo mover, a fully autonomous delivery van. The modularization interfaces of the body concept are shown in Figure 7. The bodywork platform of the UMV offers the variability in scalable front and rear modules, variable greenhouse sections, and length variability. The common parts strategy for e.g. the UMV Basic and UMV Peoplemover shows that only the specific body components – roof, roof frame, roof cross member, and side frames – have to be changed in order to build the two derivatives on top of the UMV platform. The other body parts remain the same [7], [13], [14].

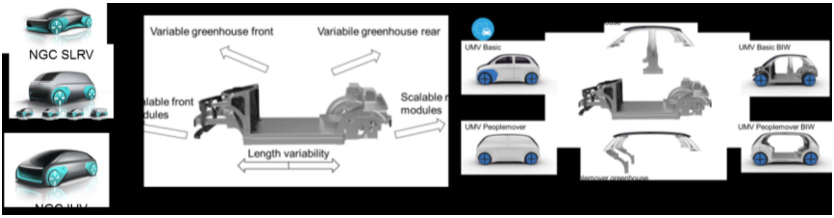


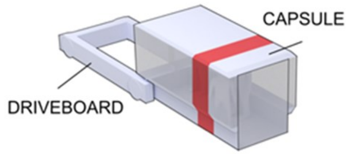
Figure 7: NGC concepts and UMV modularization strategy [14].

MAUDE: a concept for on-the-road modularization

We propose a new vehicle concept called "MAUDE"[4] to solve urban transportation problems, which is based on a dynamic otr modularization. The DLR[5] system provides new designed key functions integrated in the otr modular vehicle concept, such as an integrated lifting system or standardizable multi-purpose capsules. MAUDE consists of an autonomous, driverless, and electric driveboard and separated capsules for the transportation of goods and people (Figure 8 and 9). The **driveboard** integrates all components and systems required for autonomous driving, capsule handling, and charging. Figure 9 shows the driveboard's main components: (1) rear wheel with suspension, (2) front wheel drive and (3) battery. The lifting system, based on an adjustable chassis, is installed into the U-shaped driveboard, not in the capsule – this is based on a demand analysis and a major distinction to existing concepts and results in a significant reduction of the capsule costs. This complicates the packaging, however, since all functions and system have to be integrated in a very limited space. Technical aspects of MAUDE are addressed in [15].

Figure 8: MAUDE –design renderings for different applications (individual, public transport, and goods delivery) (own visualization).

[4] Modular, Autonomous, Updateable, Disruptive, Electric
[5] DLR is the German abbreviation for „German Aerospace Center".



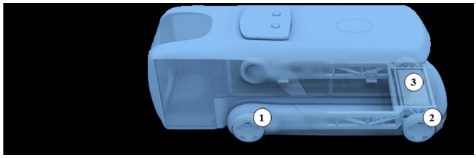


Figure 9: MAUDE – concept (own visualization) and driveboard components ([15]).

Possible applications could range from e.g. public transport, parcel delivery, retail delivery, transporting tools and material for craftsmen, to recycling with dedicated disposal-capsules. A lot of different **capsules** will be necessary. For all use-cases, accessing the capsule on ground level is beneficial as it e.g. 1) supersedes future loading ramps for urban retail and 2) allows disabled people to access the vehicle. Our lifting system as well as our capsule design makes this possible. All the different capsules have the same outer dimensions (especially length and width), so that they fit on every driveboard, whereas their interior is designed for specific applications.

The interfaces for mechanic-, electric-, and data-connection have to be standardized for every driveboard and capsule. For some application, such as public transport, an additional battery inside the capsule is necessary for e.g. air conditioning or extending the driveboard's range. As the driveboard will be the same for different capsule types, and thus the same for different applications, the chassis has to be designed for zero payloads as well as for transporting a capsule full of people or goods. Depending on the use case the capsule can be designed with an overhang for more space (Figure 8, middle). However, this overhang poses a great challenge for automated driving functions, as sensors on the driveboard can no longer "look back". Because the capsules shall remain low-cost, as many sensors as possible need to be implemented in the driveboard and sensors for control and safety are planned in the infrastructure. In critical situations a control room would intervene by remote control. Our further research will focus on the question how many (if any) sensors, and at which cost, we need in the capsules to execute all required driving maneuvers. Initial technical solutions for this vehicle concept are discussed in [15].

The consequent otr modularity allows for utilizing the expensive driveboard around the clock. Our vision is that there is an urban fleet of driveboards and a large amount of different unique capsules. A model range of driveboards in several sizes has been established. This opens the way for many new business opportunities.

Possible business models

Like other organizations, we see the future of mobility more in switching from possessing vehicles to sharing rides or cars, thus increasing efficiency. Mobility-as-a-service is a fundamental element of all of our discussed business models. The otr modularization is perfectly suited for the shared use of driveboards, which are thus used to capacity. The capsules could be shared or privately owned, depending on the business strategy. We think of various possible **applications** our proposed solution can handle:

- Transportation of people in public transport as people-movers / shuttles (Figure 8). In this case, the capsule needs an overhang for a barrier-free side entry from the boardwalk and air conditioning as well as passenger information systems.
- Transportation of individual persons (replacement for the car) in a private (Figure 8) or shared capsule (e.g. new small office-capsule). This use-case has similar requirements as the previous.
- Delivery of parcels. A capsule integrated into an apartment building as a parcel post box is in discussion.
- Delivery of goods for retail (Figure 8). City hubs could be supplied with full capsules. Last-mile-systems would transport stillages to the stores.
- Delivery to supermarkets. These capsules would need cooling units. Due to the electric propulsion, night-delivery becomes an important option.
- And many more, like capsules for craftsmen, disposal capsules, capsules for food trucks, event-service capsules, or capsules for ambulance service.

Players in the field of urban mobility have different **business model**-opportunities with our otr modular vehicle concept: 1) producing driveboards and / or capsules, 2) offering a fleet of driveboards to business (and private) customers with or without capsules, 3) execute tasks (people / goods transport) with privately owned or shared driveboards and capsules, 4) maintaining the equipment, or 5) managing a central control room supervising driveboard-fleets in the city. One of the main benefits is the autonomous driving, which supersedes the need for expensive drivers. This is critical not only financial-wise, but also because there has been a persistent trend of driver shortages lately [16].

One possible business case is described in detail now. The new business combines the operations of a hauler and a public transport operator: a company, who offers transportation services to companies in public transport, parcel delivery, and supermarket delivery, has a fleet of driveboards and some capsules for people transport (including 10% equipment on reserve). Capsules for parcels and goods delivery will be provided by the business customers, as these capsules will remain either at their hub or at the stores, respectively the apartment buildings.

There are some weaknesses in the public transport system. Foremost, there are peak-phases when the busses are overloaded (mostly commuting) and other times when busses drive nearly empty. In this business model the hauler would support local **public transport**-operators in peak-times with a people-mover capsule, thus reliving the bus operators, who can reduce their bus fleets in consequence. These peak-times are a challenging factor in scheduling the driveboards. Whenever there are off-peak phases the driveboards execute other tasks, but in peak phases the public transportation has priority. For scheduling the tasks it is essential to keep in mind that for **parcel delivery**. There has to be always a filled parcel post box in the morning. Residents need to have the opportunity to access the capsule all day for getting their mail or depositing returns. Express deliveries by other postal companies could be placed in the capsule if the residents are not at home. One issue is that the mail gets carried back to the hub if the resident has not emptied it. At the hub it will be filled up and is carried back to the apartment the other day. Initial estimates indicate that a capsule with an assumed size of 2750x1350x1250mm³ can contain 100 small, 22 medium and 1 very large compartments as well as one service terminal. For the **supermarket delivery**, pallets or lattice boxes can be dragged out of the capsule at ground level – from logistics point of view, the better urban way of delivery. Thus, future supermarkets can do without loading ramps – city stores often lack a loading ram anyway. In the business model, supermarkets are served two times a day: once at night and once during the day. At night, the capsule is only deposited while the driveboard continues directly – unloading takes place in the morning. During the day delivery (for a subsequent delivery of perishable goods) the capsule remains on the driveboard as it is today. First findings, showed a remarkable high **need of capsules**. On average, one driveboard corresponds in this business model to 7.75 capsules. In comparison: in Germany, an average of 1.6 semitrailers were fitted to one truck in 2018 [17]. This confirms the otr modular approach to separate driveboard and capsule, while keeping the capsules low-cost. The calculation is based on the assumption that the driveboards operate almost 24 hours a day. This is possible by utilizing batteries in the capsules, which work as range extenders to the battery in the driveboard. The driveboard's battery is needed foremost when the driveboard drives without a capsule or simple capsules without capsule-battery. The capsule's batteries can be charged battery-friendly at low power as they are most of the time parked. There has to be found a use-case specific balance between the additional costs for batteries and charging infrastructure and the higher utilization rate of the driveboards.

Juxtaposition of on-the-road modular vehicle concepts

In the following we will discuss distinctions between our approach, MAUDE, and other otr modular vehicle concepts. A systematic categorization based on selected characteristics can be found in Table 1.

Table 1: Juxtaposition of on-the-road modular vehicle concepts.

	Use	Standardization	Loading	Module change
Snap (Rinspeed)	Flexible (various purposes)	Individual solution	Lateral	Vertical, lifting system in the capsule
microSNAP (Rinspeed)	Flexible (various purposes)	Individual solution	Lateral	Vertical, auxiliary robots needed
Vision Urbanetic (Mercedes Benz)	Flexible (various purposes)	High potential	Back, at ground	Forward (gauge actuation)
BEE (Continental)	People- and Cargo-Mover	Individual solution	Front	Auxiliary robots needed
Pop.Up Next (Airbus, Audi, Italdesign)	People-Mover	Individual solution	Lateral	In the high, lifting done by a drone
MAUDE (DLR)	Flexible (various purposes)	High potential	Back or side, at ground	Forward, lifting system integrated in the driveboard

MAUDE is built specifically for flexible use case scenarios, including individual and public transportation as well as urban commercial traffic. This is enabled by a standardizable capsule and the possibility to access the capsule at ground level. MAUDE is equipped with capsules which have a flat ground, as they are more suitable for everyday applications, especially for cargo transport. Concepts which lack a flat ground, give away a lot of loading space. The incorporation of already standardized capsules, like ISO-containers, would be ideal. In urban applications, accessing the capsule at ground level is a major benefit. MAUDE capsules can be accessed at ground level from the back or even from the side (capsules with overhang). As of our perspective low-cost capsules are a key factor for a successful market penetration. This is why MAUDE integrates the lifting system in the driveboard, while other manufacturers integrate it in the capsule or infrastructure.

Summary and outlook

Great efforts are being made to develop new mobility solutions that can improve (urban) traffic issues of today, such as congestion or air pollution. Ground based concepts reach from people-mover built upon modular production-efficient platforms, over on-the-road (otr) modular vehicle concepts to aerial robo-taxis or future train concepts like the hyperloop. On the basis of a demand analysis for the current urban transportation situation, vehicle concepts which carry application-specific transportation units on standardized platforms seem particularly suitable for the future. Ex-factory modular vehicle concepts cannot offer a dynamic capsule-change. Therefore, we propose MAUDE, an otr modular vehicle concept that separates the driveboard, which includes all costly functions and systems, from capsules, which are low cost and can be designed for specific transportation tasks. In contrast to other otr modular concepts, our lifting system is integrated in the driveboard and is designed specifically for a ground-level access to the capsules, which is beneficial for urban logistics.

Most likely, in the future a mixture of different mobility solutions will coexist: otr modular operators, conventional public transport operators, haulers, trains, subways, individual owned cars, drones, ropeways, etc. To combine them to an efficient door-to-door transportation system, new concepts for multimodal transportation will arise. MAUDE could be linked to other transportation systems for very high inter-modality, e.g. to rail- or ropeways or maybe even aircrafts. Our future research will focus i.a. on linking MAUDE with next generation train (NGT) concepts. This way, logistic hubs like in Figure 10 can evolve to swap cargo capsules easily from the rail to the street.

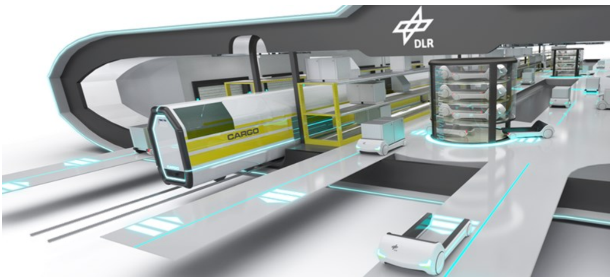


Figure 10: Logistic center for Next Generation Train and MAUDE.

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