



# Urban Vehicle Concepts for the Shared Mobility

Urban mobility concepts of the future require new forms of businesses that will ideally consist of the old economy and new economy, and also provide a close connection to the socially relevant futurology. For new vehicle concepts of car sharing this means that all cost-inflating factors must be recorded and analyzed. FH Aachen, share2drive and FEV provide an outlook on the future vehicle class of Personal Public Vehicles as a „Rolling Device“.



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## AUTHORS



**Prof. Dr.-Ing. Thilo Röth**  
is Head of the Automobile  
Technology Lab for Vehicle  
Concepts and Body Technology at  
FH Aachen (Germany).



**Dipl.-Wirt.-Ing. Michael Pielen**  
is Head of Vehicle and Mobility  
at share2drive GmbH  
in Aachen (Germany).



**Dipl.-Ing. Klaus Wolff**  
is Vice President Vehicle at  
FEV Europe GmbH in Aachen  
(Germany).



**Thomas Lüdiger, M. Sc.**  
is Senior Consultant at FEV Consult-  
ing GmbH in Aachen (Germany).

## URBAN MOBILITY AS A SERVICE

Currently, the topic of shared mobility is one of the most important trends in the automotive industry. In the so-called Urban Mobility Trait (UMT) all essential forms of urban mobility services can be described from the point of view of individual mobility needs, and business models can be evaluated with special vehicle concepts, **FIGURE 1**.

For example, free floating car sharing is a mobility service where customers (as drivers) share vehicles which are provided by companies. The travel distance is mainly comprised of short distances of less than 8 km, with only a small number of passengers being carried. With the

so-called ride selling, which includes the services offered by Uber or Lyft amongst others, private individuals are provided with chauffeur services using the service provider's own vehicles.

The final selection regarding the ultimately utilized mobility service is made by the customers according to their specific needs. Thereby, the focus is on simplicity paired with convenience and possible additional benefits (for example, using travel time for private or professional organizational tasks), the cost of the travel and the speed at which users can reach their final destination, **FIGURE 2**.

Thus, innovations in transport service are required. share2drive GmbH, headquartered in Aachen, Germany, follows this trend. It is a young company that was derived as a spin-off from the University for Applied Sciences Aachen. The company's purpose is to provide innovative mobility concepts in the car sharing sector. A core component of the business model is the PPV (Personal Public Vehicle), a vehicle that was specially developed for use in car sharing applications. In very close cooperation with FEV and its subsidiaries which have more than 4500 employees, a new player for holistic mobility solutions has emerged on the market.

## BUSINESS MODELS FOR THE SHARED MOBILITY OF TOMORROW

New mobility services in the context of UMT will have a disruptive influence on the existing value-added structure within the automotive sector. Through this, established mobility service providers are seeing an increasing amount of competition from entities from the ICT- and energy sector, which are pushing into the mobility market with new business models. Established OEMs from the classic automotive industry have conceived the initial drivers for this environment. At the same time, the automotive supplier industry – especially the large tier 1 suppliers – is reorienting itself to adequately react to market changes, for example, those posed by new vehicle manufacturers.

In addition to further diversification of vehicle models for end customers, OEMs will increasingly focus on vehicles for mobility service providers [1]. Several studies are giving prediction that by 2030, 10 % and more of all vehicles

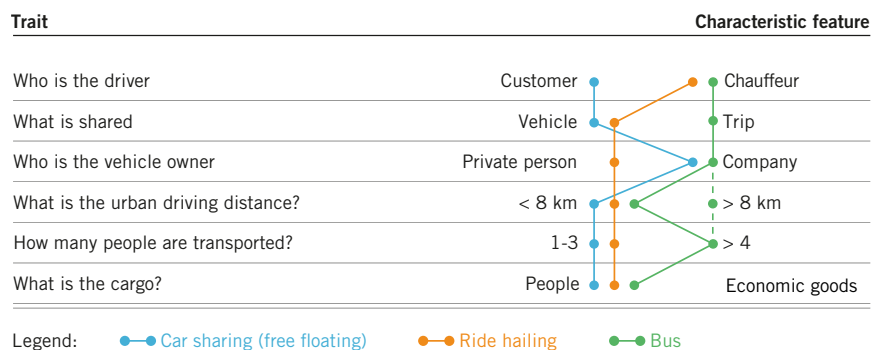


FIGURE 1 Different forms of personal mobility according to the UMT (© share2drive)

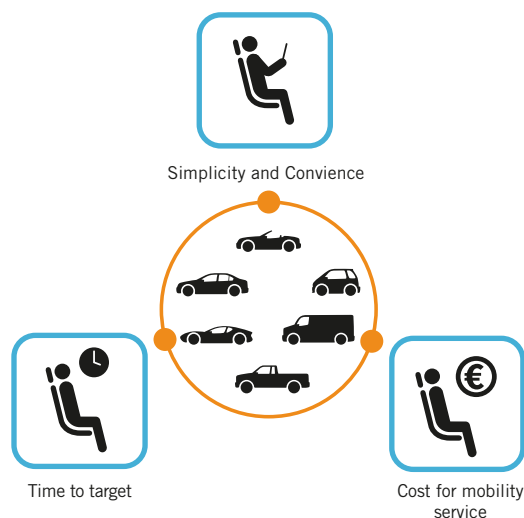


FIGURE 2 Customer-specific selection criteria for a specific type of urban mobility (© share2drive)

worldwide will be used in mobility services [2]. The race for vehicle models for this sector has begun.

According to UMT, it is important to clearly differentiate whether the concept targets so-called purpose vehicles in the sense of “Sharing a Vehicle” and “Sharing a Ride” as well as a “Driver on Board” or “Be the Driver” option. Only vehicle concepts that offer a solid market penetration combined with an attractive Total Cost for Ride (TCR) will ultimately be marketable. For a new vehicle concept, this means that all cost-inflating factors, including the vehicles, their maintenance, infrastructure, ICT expenditure and the actual operation must be recorded and analyzed. These costs must be depicted in an economic business model, and the impact of a respective vehicle design must be taken into account for each of the factors mentioned. In accordance with this approach, this publication will provide an outlook on the future PPV vehicle

class as an interface between public and individual traffic.

#### REQUIREMENTS FOR DEDICATED SMALL SHARED VEHICLES

The (electric) vehicles used in urban mobility services to date, are only able to fulfill their deployment purpose to a limited extent, since they were originally designed for the end-customer use. Thereby, fleet operators only carry out minor modifications, which especially focus on the actual vehicle access to vehicles themselves. However, in the course of its use within an urban shared mobility concept, the specific requirements of operators and vehicle users are becoming increasingly important. At the same time, vehicles in new mobility services must be understood as “Rolling Devices” in a multimodal world. As a result, the requirement profile of a “perfect” shared vehicle should not be based on the conventional customer analysis,

but rather on a mobility concept as well as a business model. FIGURE 3 shows the process of the specifications formulation for the PPV 1.0.

Requirements from the car sharing operation were conducted in joint research by the University for Applied Sciences Aachen and Cambio Aachen, and also based on publications from the Bundesverband CarSharing e. V. (Federal CarSharing) [3].

#### CONCEPTION OF THE PPV 1.0

The paramount goal of the PPV concept is to develop a realistic vehicle that does not follow the current trend of “non-viable” show cars, but is rather a modern response to the shared mobility requirements of the future. The vehicle specifications booklet prepared for the PPV 1.0 addresses a European homologation. The development process is founded on the ECIE standard regarding the package engineering. During the concept development phase, a modular and easily modifiable interior buck is also used on the hardware side to verify the demanding interior specifications. The functional targets (for example for crash cases) are secured by appropriate FEM simulations with LS-Dyna.

#### DIMENSIONAL AND STRUCTURAL CONCEPT

The greatest design challenge is created by the mobility specifications for a vehicle in the M1 class, which may only have a length of <2.5 m (cross parking permitted) and a width of approximately 1.7 m. At the same time, in order to enable 95 % of all conceivable travels, three people have to be accommodated in the PPV 1.0. The stipulation that the interior should offer a friendly, generous interior space further complicates the overall design process.

The PPV achieves this design feat with a one-box design and a three-seat arrangement (1+2-seater) in a row. The powertrain is designed to match the constraints of the floor assembly in a highly integrative and package-efficient manner. A new type of body-in-white concept allows the windscreen to be placed far forward. An important conceptual feature is the recessed A-pillar and very large glass surfaces. Another component of the body concept is the driver’s door.

Requirements from the CarSharing mobility concept	Requirements towards the PPV
<ul style="list-style-type: none"> <li>- Broad target groups (18-40 year olds especially in the focus)</li> <li>- High recognition value</li> <li>- Modern, not playful, conveyance of safety</li> </ul>	<ul style="list-style-type: none"> <li>- Independent, clear design</li> <li>- Friendly appearance</li> </ul>
<ul style="list-style-type: none"> <li>- 80% "single travel"</li> <li>- 95% Rides with max. 3 people</li> <li>- 86% Use to transport purchases</li> <li>- Minimal parking space requirements (cross parking!)</li> </ul>	<ul style="list-style-type: none"> <li>- 3-seater (1+2) at 2.5 m length</li> <li>- Variable useable space (e.g. baby buggies, bicycles)</li> <li>- High parking space packaging density</li> <li>- Comfortable entrance &amp; exit (parking!)</li> </ul>
<ul style="list-style-type: none"> <li>- Very broad driver population</li> <li>- Very simple operation</li> <li>- Removal of obstacles and barriers</li> <li>- ~50% are "infrequent drivers" (use 1-5 times/month)</li> <li>- Creation of a "quick" feel-good atmosphere</li> <li>- Intensive communication (operator, user, infrastructure vehicle)</li> </ul>	<ul style="list-style-type: none"> <li>- Ergonomics for everyone</li> <li>- "Super Simple to Use" and intuitive IT HMI</li> <li>- No distraction due to vehicle operation</li> <li>- High degree of personalization</li> <li>- Integration of the PPV into the Cloud</li> <li>- Generous, airy interior space</li> </ul>
<ul style="list-style-type: none"> <li>- Ten user changes per day per vehicle</li> <li>- "Careless" handling of the vehicles</li> <li>- The most frequent accidents are minor damages during parking</li> <li>- High urban agility</li> <li>- Highest degree of urban vehicle safety</li> </ul>	<ul style="list-style-type: none"> <li>- Integrated cleaning concept</li> <li>- Rugged</li> <li>- Resilient in case of minor damages</li> <li>- Turning circle &lt;8 m; high performance up to 80 km/h</li> <li>- Highest degree of passive and active safety</li> </ul>
<ul style="list-style-type: none"> <li>- No more expensive than a conventional vehicle, despite e-drive</li> <li>- Wireless charging</li> <li>- max. 80 km/day &amp; 10 users/day &amp; 24/7 availability</li> </ul>	<ul style="list-style-type: none"> <li>- &lt;0.60 €/km (Berlin)</li> <li>- Integrated business model</li> <li>- Investment friendly production</li> </ul>

FIGURE 3 Derivation of vehicle requirements from mobility and business model needs (© share2drive | FH Aachen)

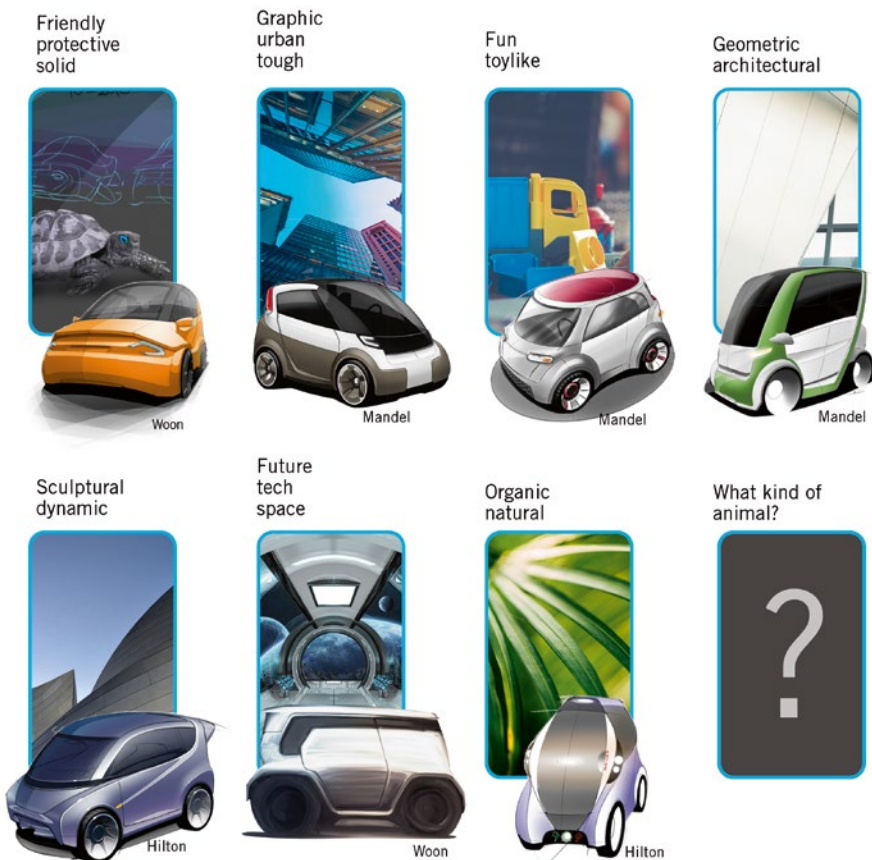


FIGURE 4 Selected association worlds in the styling development of the PPV 1.0 (© FH Aachen)

A new type of swing-sliding door concept guarantees a best-in-class door opening, even in narrow parking spaces without protruding beyond the very short vehicle when opened.

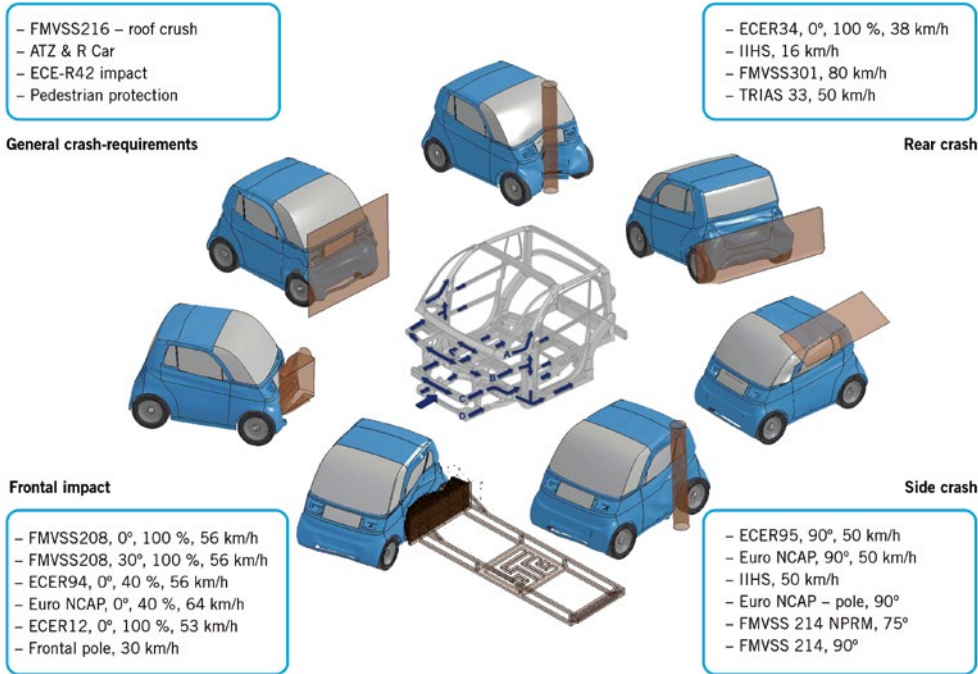
## STYLING CONCEPT FOR EXTERIOR AND INTERIOR

Prior to the actual styling development, a styling DNA of the PPV 1.0 was defined within an interdisciplinary design team. Urban association worlds were created under the heading "What kind of Animal?", FIGURE 4. Approximately 250 styling drafts were developed for these very different urban world concepts, which were then condensed down to two fundamentally different concepts of the preferred association space, which then led to the final concept decision. From the conceptual decision onward, the styling development was carried out using a typical digital CAS process (computer-aided styling). The envisioned styling DNA could be implemented in the final styling. In summary, the PPV can be described as the smallest self-propelled bus in the world.

The interior concept differs distinctly from the exterior in terms of styling language, and assumes the reduced communication DNA from the bus construction and the IT world to a great extent. With the PPV 1.0, the total number of control elements has been consistently reduced to an absolute minimum, and the paramount focus was on the intuitive operation. The driver's seat features a modern and digital HMI. The air-conditioning concept is oriented more towards the way urban spaces function, and not towards classic vehicle construction. A TCR-optimized cleaning concept for the interior, reasonable variability through the two-seater bench, omission of dirt-prone gaps, surfaces from the boat construction, a spray-on floor from rail vehicle construction, as well as the consequent omission of "unnecessary" storage areas characterize the interior as a genuinely useful car sharing environment.

## DRIVE CONCEPT

The drive concept of the PPV 1.0 is mainly based on a combination of solid state-of-the-art technology components for an electrically powered urban city



**FIGURE 5** Crash protection of the PPV for the EU market and for additional urban accident scenarios (© Imperia)

vehicle with 400-V technology. The technical specifications are very competitive, with 45 kW of drive power in the front, a maximum speed of 120 km/h, and a battery pack with nearly 20 kWh. The range is 80 km – even under extreme conditions – and it has been verified according to a specially developed car-sharing cycle. In accordance with the hare2drive business model, the approximately 2 h of operation required daily can be achieved reliably. The wireless charging capability is insured through the so-called flex share of share2drive. The concept of a tandem motor arrangement with two small electric machines in the front of the vehicle is founded on the crash behavior advantages, and the requirement to deliver an agile city vehicle.

**SAFETY CONCEPT**

In addition to a large number of accident prevention measures, the PPV 1.0 is characterized by high crash safety, **FIGURE 5**. The particular challenge in the development of the concept lies in the superior design implementation of the frontal crash requirements. The very short front end requires the development to pursue a radical structural design with four load path levels and a very controlled deformation behavior. With

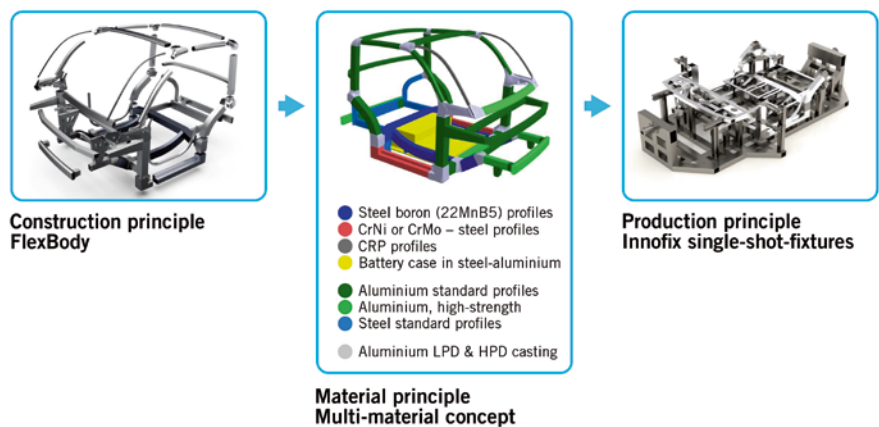
a total deformation of approximately 350 mm, an average crash pulse of 31 g is achieved with approximately 60 mm firewall intrusion.

In the event of a side impact, the deformations are diverted from the centrally arranged battery structure. For the roof indentation test according to FMVSS 216, the crash strength is met with just under 60 kN.

**BODY STRUCTURE AND PRODUCTION CONCEPT**

The body-in-white is based on the so-called FlexBody, a body design kit

which enables the construction of profile-based lightweight design vehicle bodies using a multi-material body with less than 10,000 vehicles per year. Thanks to a standardized process and the strict separation of the profiles and nodes, FlexBody allows the development of vehicle body structures and their preparation for production in a very short time. The biggest advantage lies in the very low investment requirements. The FlexBody of the PPV 1.0 primarily utilizes steel-based, high-strength and ultra-high-strength materials in the floor assembly. In the vehicle front and body are primarily comprised of aluminum



**FIGURE 6** Structural concept – FlexBody as a multi-material lightweight design body (© Imperia)

solutions. A so-called ladder-integrated frame protectively seats the centrally positioned battery.

The static torsional stiffness of the 140 kg body is at a high level with a lightweight quality of approximately 3. The body shell is manufactured in so-called Innofix single-shot fixtures and is designed for the use of a newly developed injection bonding process. The production of the 7000 annually planned PPVs is carried out in a two-shift operation.

## OUTLOOK AND PPV 2.0

The market development regarding new mobility solutions offers an interesting potential for concepts where mobility needs, new business models and vehicle construction are able to merge. The highly positive response to the PPV 1.0, which offers an answer to future mobility needs as a special vehicle solution in a shared economy by 2020, has already induced the work towards the creation of the PPV 2.0.

In conventional vehicle design, the rapidly advancing development of autonomous driving provides significant advantages when it comes to the customer benefits comfort and safety. In a shared mobility world, autonomous driving functions are valued to an even greater degree as an “enabler” in a world of “street furniture” and the logistical mastery of people’s mobility needs.

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