Car-sharing in the context of car operation

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Abstract. Short-term car-sharing rentals are becoming increasingly popular in the urban transport systems world-wide. Along with their development, the existing concepts are being also improved e.g. by means of introducing new fleets of vehicles, improving the task-oriented efficiency of vehicles, as well as by maintaining the economic capacity of the system. According to the recent trend, many scientific studies are undertaken with an attempt to analyse various social, environmental or economic aspects related to the practical introduction of these systems. The niche area still to be exploited, however, is the research focusing directly on vehicles, i.e. a fleet of vehicles used in car-sharing systems, and on the issues related to its operation. The authors have focused basically on compiling a list of the most frequently used vehicles in car-sharing systems, defining vehicle classes and determining the type of their propulsion. Then they developed a list of maintenance issues, including daily service. Furthermore, they attempted to provide an inventory of main damages that may occur in car-sharing vehicles depending on the given vehicle mileage. The paper finally aims at raising awareness among the users of these systems regarding the activities related to the operation of a motor vehicle and its regular service.

1. Introduction

Short-term car rental services, called car-sharing systems, are becoming increasingly common means of urban transport. With their rising popularity, the operators of such systems introduce systematically numerous improvements to the functioning of services in order to fine-tune their offers to the requirements of their present and potential customers. These changes are related e.g. to various technological and transport aspects (e.g. expanding the fleet of vehicles with new car models, or using electric or hybrid vehicles), as well as to economic and performance issues [1].

According to the recent trends, car-sharing systems are analysed by researchers with reference to economic, social or environmental factors, based on the assumptions of sustainable development, as mentioned in [1-8]. However, there still exists a niche research area observed by the authors in the process of the literature review. It is connected strictly to the operational issues pertinent to the functioning of vehicle fleets in car-sharing systems. Therefore, the authors decided to carry out their research with the focus on the operation of vehicles used in car-sharing systems. The paper is dedicated to the analysis of the fleet of vehicles existing on the European market of organized car-sharing operators, however, excluding the system of peer-to-peer car-sharing (Peer-to-peer car-sharing (P2P) – a process whereby by which existing car owners make their vehicles available for others to rent for short periods of time [9]). Based upon the results of this research, the authors combined a list of the most commonly used vehicle classes and their models.

Based on the information received about the use of vehicles in car-sharing, the authors prepared a list of activities that should be performed while servicing vehicles on the daily basis. In addition, the
most frequent types of damage (defects) of vehicles were also analysed and listed. The aim of the research is also to raise the awareness among the users of these systems regarding the activities related to the operation of car-sharing system vehicles and their regular service during the rental period.

2. Car-sharing – some basic information

Car-sharing systems form a specific model of car rental agencies working on the basic principle of providing services for a short period of time. Typically, that period lasts from a few minutes up to one hour [10]. This business concept of car-sharing systems dates back to 1948 [11], however, the systems gained their popularity in the 20th century mainly as a result of the sustainable transport development and the occurrence of sustainable consumption [12].

From the perspective of the urban traffic management, car-sharing has created an opportunity for the improvement in mobility as well as has made an attempt to limit the number of private vehicles entering city centres [13]. Currently, the worldwide market offers a number of various business models of car-sharing systems. It means that car-sharing services can be provided by organized companies, agencies or by cooperatives owned and managed by groups of people whose business intention is to share their own private vehicles or lend them from others, and do so via a dedicated internet platform [14].

The whole principle of sharing a vehicle is based on performing some simple steps which include: the registration in the system of a particular operator, the verification of one’s permission to drive (a driving license) and the identification of the user (e.g. an ID card or a passport), then finding an available vehicle on the map shared by a particular operator with the use of a mobile application or via a website, and finally making the vehicle reservation.

The next step is to reach the vehicle at the time specified by the operator and to open the vehicle in compliance with the procedures defined by a particular operator, e.g. by scanning the QR code (QR code - Quick Response Code - is the trademark for a type of a matrix barcode; a pattern of black-and-white squares that is printed on something and that can be read by some types of mobile phones and thus provides some information to the user of this smartphone [15]). Varying on the operator’s set of rules, the user has then a certain amount of time (about 2-3 minutes) to complete a checklist of the vehicle technical condition. This time is free from charge, from the time of opening the vehicle to the time of starting the engine. While performing this process, the user should: inspect the vehicle from outside, and in case of any damage found, complete the damage report [16]. In addition, at this time the user should also assess the appearance and cleanliness of the vehicle interior [16]. Furthermore, it is also important to check whether the vehicle is equipped with a first aid kit, a reflective vest, a fire extinguisher and a warning triangle, as well as the registration document and the car key (if the use of the vehicle requires so) [16] [17] [18]. Then, upon completing the above verification process, the user is required to get prepared for driving by adjusting the driver’s seat, mirrors, steering height, fastening the belt and switching on dipped headlights [16].

In the event of any vehicle faults or insufficient equipment, the user should contact the operator customer service. Issuing a negative assessment of the vehicle technical condition is normally associated with the termination of the rental agreement without incurring any costs. The user shall not fail to report any defects or faults occurring while driving, e.g. if signalled by a check engine light; such a practice is strictly forbidden and in such circumstances, driving of the vehicle is done solely on the user’s own responsibility [16] [17] [18].

Depending on the operators, a fleet in car-sharing systems may consist of vehicles equipped with classic, hybrid and electric drive units. An example of such a vehicle used in car-sharing systems is presented in the figure 1.
3. Use of vehicles with car-sharing

Every technical object, including a car-sharing vehicle, is subject of wear during use. Operating the vehicle exposes faults occurring already during the process of design and assembly. Appropriate handling of any technical facility allows for timely restoration of its technical efficiency at the stage of use. Ensuring a proper technical condition of the vehicle depends to the same extent on the designer and the manufacturer; this responsibility, however, rests mainly with the end user.

The correct operation of car-sharing vehicles exerts an impact on the costs of vehicle maintenance and the length of vehicle service life in a car-sharing system. Vehicles used in a car-sharing system are subject to transient operating conditions. Operating a technical facility (a car-sharing vehicle) can be divided into two groups of activities: the vehicle use and the vehicle servicing [19][20]:

- the vehicle use,
- the vehicle servicing.

According to the car-sharing system principles, the use of a vehicle for that purpose shall be classified as the vehicle use in urban conditions. Such an assumption would then indicate the use of the A-segment urban vehicles as vehicles of choice [21].

In order to establish which fleet type is most frequently used for car-sharing, the authors analysed 40 car-sharing systems from 25 European countries, with a total of 187 various vehicles offered for renting.

The analysis focused on the organized car-sharing operators, excluding P2P systems. Based on the research analysis performed on the information provided by the fleet operators, it can be concluded that the leading types of vehicles used for car-sharing fall into the category of the C-segment [21], which represents 30% of the entire number of the vehicles tested and the B-segment [21] amounting to 27%. The obtained results have been presented on the chart in Figure 2.
Figure 2. Classes of vehicles used in the analysed European car-sharing systems. Source: author’s own collaboration.

With regard to the most commonly used vehicle classes, it can be concluded that the C-segment vehicles represent a lower average class of passenger cars, characterised by a compact design which provides, however, a relatively good comfort of travel for four adults and a moderately large luggage compartment [21]. On the other hand, the B-segment is the class of small-size passenger cars which groups ultra-compact cars, i.e. slightly larger than the smallest cars of the A-segment, but which do not meet the criteria for classifying them as a typical C-segment compact car [22].

As regards the type of a drive unit, the largest group, i.e. 72% of the analysed vehicles is powered by a classic drive unit; 28% of the vehicles were fitted with some alternative power units, including e.g. 19% of hybrid vehicles and 9% of electric vehicles. The results obtained were presented on the chart in Figure 3.

Figure 3. The type of a drive unit used in the car-sharing vehicles under analysis. Source: author’s own collaboration.

The next research objective undertaken by the authors was to check which vehicle models are most commonly represented in the European car-sharing systems. The obtained results have been ordered with respect to the type of a drive unit most frequently fitted to the vehicles offered for sharing:
- a classic drive unit - Volkswagen Golf (C-segment),
- an electric drive unit - BMW i3 (C-segment),
- a hybrid drive unit - Toyota Yaris Hybrid (B-segment).
A detailed analysis of particular vehicle models used in the European car-sharing systems is presented on the graphs in Figures 4, 5, 6.

**Figure 4.** Types of vehicles with a classic drive unit used in the analysed car-sharing systems. Source: author’s own collaboration

**Figure 5.** Types of vehicles with an electric drive unit used in the analysed car-sharing systems. Source: author’s own collaboration
The research shows that the variety of vehicles used in car sharing systems is very large. The system user should be properly prepared for driving a given vehicle prior to making a choice. Each vehicle, regardless of the model and brand, is subject to daily and periodic maintenance tasks. Consequently, it is important to make a daily inspection of a rented vehicle before commencing to drive. And following such an inspection, the next step is to make a decision whether to begin rental or to contact the customer service office. It is important to perform several tasks related to daily service which include the inspection of the following [19]: the over-all condition of the vehicle (cleanliness of the vehicle, damage to the body, the condition of tires, the housing of headlamps and composite lamps, and mirrors); the level of technical fluids in the reservoirs in the engine compartment; the oil level in the car oil sump; any additional vehicle equipment in accordance with the delivery-acceptance protocol (spare wheel, fuses, bulbs, etc.; the steering and braking system; the car lighting and direction indicators.

The time amount which should be dedicated by the vehicle driver to perform these service tasks is about 30 minutes prior to driving. Respectively, the activities related to periodic maintenance include activities from the daily operations and control, and include the inspection of the following [22][23][24]: the battery type (especially after its replacement) and the electrolyte level; the condition of tires (the tire tread pattern and the uniformity of tire tread wear); the condition of friction linings and brake pads; the clearances on wheel bearings, joints and steering wheel circumference; any causes of potential loss of engine oil (leaks).

The activities related to the above-mentioned services should be performed by every user of each vehicle, regardless of the purpose for which a particular vehicle is used. Performing the tasks related to operation, as well as a positive result of service is the basis for further safe on-road use of the vehicle. It is important, however, that while using a car-sharing service, the user only has about 2-3 minutes to inspect thoroughly the car selected. The daily service should be performed each time by the user, and the responsibility for periodic service rests entirely on the operator of the car-sharing network and its employees.

4. Using the vehicle in car-sharing and possible faults

The duration of the vehicle operation or the vehicle correct mileage to achieve limit wear is called a long period of use. All the constructors of technical objects, including vehicles, assume appropriate reliability and durability of cooperating elements as a result of their choices while selecting appropriate types and quality of construction materials. However, the durability of the vehicle is also significantly influenced by the way the driver uses the vehicle. When analysing the driving style of the car-sharing user, it has to be emphasised that while driving in city traffic and in very difficult conditions, it is the...
driver who decides about the number of violent behaviours, jerks, and braking performed, which consequently have a significant impact on the smoothness of driving [23-28].

As a result of a short-term vehicle sharing system, namely the vehicle rental for moving from point A to point B, covering short distances or just one short distance, the vehicle is exposed more to unfavourable working conditions. Fast moving of the vehicle, when the engine has not yet reached its appropriate operating temperature, and with the vehicle accelerated rapidly to high speeds, results in very unfavourable operating conditions of the engine and shortens its durability. The intensity of wear depends also on the value of the outside temperature, the vehicle idle time and the thermal condition of the engine at the time of ignition. Taking into account the method of use and the fact that the vehicle can be used by an infinite number of drivers, it is worth paying attention to the failure rate of selected vehicle models. According to the statistics gathered in Germany for 2017, the average number of user-drivers amounted to 172 per vehicle [29]. The failure of the vehicle and its improper use may result in the vehicle becoming unsuitable for use in a short-term vehicle sharing system or being even more susceptible to failure.

The classes of vehicles currently used in car sharing systems and the assumption that these vehicles are always brand-new and used only for sharing for a strictly specified period of time, means that the second-hand vehicle market offers for resale "relatively new" vehicles with a relatively small mileage, often below 50 000 kilometres; it shall be emphasised though, that despite the relatively young age of the vehicle and its low mileage, the degree of its wear may be significant. The data regarding an average vehicle use period in the system is presented in the table below.

Table 1. The average use period of car-sharing vehicles in Europe.

| Source: author’s own collaboration based on [30] |
|---|---|---|---|---|
| Car using | Day | Week | Month | Year |
| Time [h] | 6-8 | 42-56 | 186-248 | 2190-2920 |
| Mileage [km] | 7.5 | 52.5 | 232.5 | 2737.5 |

On average, an annual mileage covered by a vehicle in a sharing system amounts to less than 3 thousand kilometres. Under the Polish law, a new vehicle is required to undergo the official technical examination (at SKP, i.e. a vehicle inspection station) only after three years from the date of its first registration. The manufacturers of motor vehicles, as part of the process of maintaining the warranty for a new vehicle, require a technical inspection to be carried out at an authorized service of a given brand depending on the mileage or at a certain service interval. Currently, these service intervals amount to approximately 15-30 thousand kilometres covered, or even more, or alternatively after the period of 12 months. Therefore, there exists a concern that the vehicle technical condition may be checked only once per year for the purpose of the warranty review.

Based on the average mileage of vehicles, one shall expect many vehicle failures / faults which may pass unnoticed by the system user. As regards the C-segment and B-segment vehicles with the mileage covered ranging from 0 to 50 000 kilometres, the list of the most frequently occurring failures, based on DEKRA reports, looks as follows [31]:
- error messages recorded with regard to the exhaust system faults
- engine suspension damaged
- cracked springs
- damaged shock absorber bearings
- setting and operation of the lighting installation
- daytime running lights defective
- problems with the braking system – below limit efficiency in braking performance
- problems with the windshield which in effect distorts the visibility beyond the field of distant visibility
- hinged body joints
- oil leaks from the engine and the gearbox
- inadequate levels of operating fluids (below the required mark); and other.

That is why it is so important to draw the attention of all potential users and the service operators to the importance of performing daily, routine vehicle inspections, and periodic technical inspections respectively. An ideal solution would result in a daily inspection of each vehicle offered for car-sharing performed by the employees of a particular service operator; having in mind, however, the large size of the fleet of vehicles offered in cities, this would be an arduous or even infeasible task.

5. Conclusion and further research

In conclusion, the analysis of the car-sharing systems offered in Europe, as well as the data on the average time and mileage of vehicles, showed that the vehicles used in such systems can be subject to significant wear. In addition, due to the specificity of the car-sharing business principle, these vehicles are used by a large number of people on a daily basis. Furthermore, each driver of the car-sharing vehicle may be characterized by a different driving style, skills and habits that the driver uses regularly and persistently. Therefore, based on the list of faults which are characteristic for the B-segment and the C-segment vehicles, and with regard to the users' own safety and the user's liability for damage caused during vehicle use, it is particularly important to draw the attention of users and employees of car-sharing operators to verify scrupulously the technical condition of each vehicle prior to use.

In addition, before using the shared economy service, it is important to know the rules and procedures applicable to a particular type of a vehicle [32]. This information, especially in the case of electric vehicles, is particularly important when connecting / disconnecting cars to chargers, leaving them for a loading period or dealing with various vehicle equipment issues, e.g. additional power cords (electric vehicles), refuelling adapters (gas-powered vehicles e.g. LPG [33][34]). It would also be highly recommendable to introduce a code of good practice with a list of steps / tasks to be followed by each potential user prior to driving. Such actions would not only result in an increased security provided for users, but would also improve significantly the efficiency of the vehicles offered by the service operators. Subsequently, the authors plan to focus their further research on the operation of car-sharing vehicles from the global perspective, as well as to analyse the issues related to appropriate vehicle equipment and education while using vehicles from car-sharing systems with a particular emphasis placed on electric vehicles.

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