Product-Service System for Autonomous Vehicles: a preliminary typology studies

Fabio Antonialli, Bruna Habib Cavazza, Rodrigo Marçal Gandia, Joel Yutaka Sugano, André Luiz Zambalde, Isabelle Nicolaï, Arthur de Miranda Neto

Product-Service System for Autonomous Vehicles: a preliminary typology studies

Fabio Antonialli, Bruna Habib Cavazza, Rodrigo Marçal Gandia,
Joel Yutaka Sugano, André Luiz Zambalde, Isabelle Nicolaï, Arthur de Miranda Neto

1. Introduction

The development of Autonomous Vehicles (AVs) is an important innovation that promises to have a great impact on the issues of urban mobility. In the specific case of higher levels of automation – such as levels 4 and 5 – as defined by SAE (2016), the vehicle can travel without the intervention of a human operator (driver). It should be noted that in most studies and current tests, AVs are likely to be electric vehicle that integrates, in addition to the benefits of its own automation, the benefits of an electric mobility that does not pollute the environment during trips as combustion vehicles do.

When it comes to AVs, it is necessary to distinguish two important ruptures: the first refers to the vehicle connected to its infrastructure (that is, its entire traffic environment), and both connected to the Internet (Internet of Things - IoT), in order to make the commute more pleasant and above all, safer. In this context, driver assistance systems are introduced, allowing the driver to better manage difficult and even dangerous situations. In addition, it is important to highlight the rapid development of the automotive 2.0 concept, which proposes changes to the vehicle as not only a mechanical assembly, but as an intelligent, connected platform architecture that contains equipment, services and support applications to improve the user experience (Dellios and Patsakis & Polemi, 2016), resulting in new concepts such as vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I).

The second rupture is directly related to vehicle autonomy, in which it is intended to develop a vehicle that no longer needs a driver. Several developments in the area evidence the progress of these vehicles, pointing to their imminent arrival in the near future (Anderson et al., 2016; McKinsey & Company, 2016; U.S. Department for Transport, 2016). The current state of the technology, coupled with the expected improvements and plans already announced by several Original Equipment Manufacturers (OEMs) and other stakeholders, make it likely that fully autonomous vehicles will be available to mainstream consumers by mid-2020s (Anderson et al., 2016).

In general, the AVs use a procedural design called "feel-plan-act", in which, by understanding their environment, they are able to employ a combination of sensors (Anderson et al., 2016), such as driver assistance, geolocation, among other factors that will also allow a completely new opening for the commercial and advertising dimension in perfect adaptation to the occupants of the vehicle. Preventive systems will monitor the occupants' health, anticipate maintenance of the vehicle, propose alternatives for leisure and work or sales of new and original products and services.

There are several innovations to come, as well as the creation of new demands, with the inclusion of specific publics that are currently not present in the market, such as the disabled or the elderly, ensuring a completely new perspective in terms of mobility. In fact, there is a strong expectation that in the future, AVs can be used to provide accessibility for people in need, reducing costs and time in transportation systems, and offering comfort to those who do not want or can not drive (Mutz et al., 2016).

These new AVs trends are concomitant with the generalization of the service economy in which owning a car will no longer be seen as a priority for users, particularly for urban citizens. The traditional transport model, dominated by cars, taxis and buses, may suffer an exponential decline in the coming years, giving rise to "intermediates" means of transport, mostly designed around the concept of sharing (Enoch, 2015). In this sense, the car tends to be increasingly shared and the "mobility" function becomes the focus of market analysis. In this context, having a shared AV vehicle can result in significant benefits: the AV after completing a commute can, for example, return to the fleet and recharge its battery or depart for a new mission. This opens up an economic and environmental potential that can and should be explored.

Innovations like these lead to imagining mobility in new ways, and can be "freshly" interpreted as a combination of two parameters: personal and shared vehicle and personal and shared trips. Such evolution goes beyond of seeing the AV simply as a new product, but rather to consider mobility as a Product-Service System (PSS) being this an object of innovation. Manzini and Verzzoli (2003) conceptualize PSS as an innovation strategy that alters the focus of the business of designing (and selling) only physical products, to designing (and selling) a system of products and services that are jointly able to meet specific customer demands, where customers' demands are met by service satisfaction, rather than the supply of a product.

This paradigm changes towards the PSS concept (Manzini & Vezzoli 2003; Boehm & Thomas, 2013) imposes new reflections on the conditions of innovation, and raises several questions such as: Do AVs fit the PSS model? What are the characteristics of AVs from the perspective of the PSS? In this context, this paper aimed at drawing a typology model for the uses of Autonomous Vehicles in the scope of a Product-Service System by identifying their core characteristics.

2. Theoretical Background

In this section, we will present the main aspects and characteristics that are important for the understanding the AVs as a PSS. First, item 2.1 presents an overview of the Autonomous Vehicles, their emergence and evolution of the field, main concepts used and the governmental and industrial context. Next, we present the levels of automation currently used to classify this type of vehicle and some discussions about the multidisciplinary aspect of the AVs. Finally, in item 2.2 the concepts and characteristics of a PSS are described.

2.1. Autonomous Vehicles – An overview

Autonomous Vehicles (AVs) – also known as Automated Driving Systems (ADS); self-driving vehicles; driverless cars or even; robotic cars – are vehicles with motion and action capabilities that don't require any sort of conductor (driver) or teleoperation control (Frazzoli, Dahleh & Feron, 2002).

According to Lima (2015) and Kröger (2015), the earliest records of an autonomous passenger vehicle date back to the late-1970s, when, a group of researchers from the Tsukuba Mechanical Engineering Laboratory (Japan), conceived a driverless car prototype able to track white street marks with computer vision at speeds up to 30 km/h (20 mph). Another important advancement came about a decade later (1980s), under the supervision of professor Ernst Dickmanns from the Bundeswehr University Munich (Germany), they developed a visually guided autonomous car able to detect objects on the road—in front of and behind the vehicle (Kröger, 2015; Lima, 2015). Still according to these authors, in 1995, members of the NavLab from Carnegie Mellon University (USA) presented a partially autonomous vehicle that drove from Pittsburgh to San Diego as part of a project named: "No Hands across America".

The watershed though, on AVs research and development, came on 2004 in the USA with a series of public annual challenges, named DARPA Gran Challenges funded by the United States Department of Defense. By means of them, countless contributions and advances have been made on AVs throughout the 21st century (Reschka, 2015; Poorsartep, 2014).

Governments of several countries have become interested in the significant benefits of AVs. The United States was the first country to introduce legislation allowing the testing of AVs. In several countries in Europe (Finland, France, Germany, Italy, the Netherlands, Spain, Sweden and England) and globally, lawmakers are considering ways to accommodate the development and testing of AVs technologies on their roads. In the same sense, Asian countries like Japan, Singapore, China and South Korea are interested that international regulations are updated to allow the development of automated vehicle technologies (Schoitsch, 2016; U.K. Department for Transport, 2015).

As for the automotive industry, autonomous technology also represents an area of significant interest, numerous carmakers – including Audi, BMW, Cadillac, Ford, GM, Mercedes-Benz, Nissan, Toyota, Volkswagen and Volvo – have already started testing driverless cars (Fagnant & Kockelman, 2015). It is also worth noting that partnerships among companies have been a very common way for advancing the development of AVs' technologies (e.g.: BMW's alliance with Intel and Mobileye aiming on deploying a fleet of around 40 self-driving test vehicles on the road in the second half of 2017) and even for training new professionals in the field, such as the partnership among Mercedes Benz, McLaren, Otto, Nvidia and Udacity (University of the Silicon Valley) to create an online course for training engineering professionals in the area.

It should also be noted that vehicles with semi-autonomous features are already being marketed (level 3 of automation) – such as Tesla model S, Mercedes-Benz S65, Infiniti Q50S and BMW 750i xDrive – which according to Fagnant and Kockelman (2015) include collision avoidance, parking assistance systems, GPS navigation, adaptive speed control and trajectory drift warnings.

Significant advances are also being made within the academia, as pointed out by Lima (2015), Weick and Jain (2014) research centers and universities world-wide are striving to advance studies on technology mobility, vehicle-infrastructure interaction and management and business-related issues for the consolidation of autonomous vehicles.

Therefore, according to Enoch (2015), the traditional transport model (dominated by private cars, taxis and buses) it is likely suffer an exponential decline in the coming years, giving rise to means of transport called "intermediaries" (mostly designed in the form of shared vehicles) such as AVs. In this sense, AVs are inserted in the most significant historical change for the society, economy, automobile and public transport industry (Attias,2016; Schoitsch, 2016; Poorsartep, 2014).

However, it's important highlighting that the technology itself is no longer the major hindrance (Poorsartep, 2014). The major road blocks that AVs must now face are consumer acceptance and regulatory frameworks (Attias, 2016; Enoch, 2015; Schellekens, 2015, Poorsartep, 2014).

2.1.1 Multidisciplinarity of the AVs field of study

Aiming at drawing a state-of-the-art overview of publications on AVs, Gandia et al. (2017) carried out a scientiometric and bibliometric study with 6,711 papers in the Web of Science (WoS) database attempting to identify the main characteristics of the field, as well as its evolution overtime, in order to highlight potential gaps for prospective studies. Among the main findings presented by the authors, (that included a bibliometric evolution such as publications and citations overtime, most cited authors, higher publications sources; countries that most published and other analysis), we highlight here the findings that point out to the multidisciplinarity aspect of this study field.

According to the authors, there has been a growing demand and interest in the topic over the years. It was found that: 1) the field of study is heterogeneous (spreading over 126 categories of knowledge in the WoS database); 2) the topic has been widely discussed in seminars, conferences and workshops, therefore, it is far from being exhausted by the academy, which implies that; 3) a consolidated state-of-the-art has not yet been clearly identified.

It is also worth highlighting, that applied social research (with categories such as: business; management; ethics and; law, etc) are still incipient when compared to more technical applied research (such as: engineering; computer science). This was made clear by the authors by the keywords-bust analysis (Chen, 2006; 2004) that corroborates the need to extrapolate the technical research areas, in a sense that: 1) technological factors are still essential for the development of the field, however; 2) other non-technical research areas need to be better explored (post-DARPA effects) in order for such vehicles successfully reach the market.

In this sense, when it comes to the advancement of the field it is important to distinguish two main points: 1) the vehicle connected to its infrastructure (its entire traffic environment), and the fact that both AVs and the surrounding infrastructure would be connected to the Internet (IoT – Internet of Things), in order to make driving more pleasant and above all safer (Dellios; Patsakis & Polemi, 2016) and; 2) vehicle autonomy itself, in a sense that several developments in the area evidence the progress of these vehicles, pointing to their imminent arrival in the near future (Anderson et al., 2016; McKinsey&Company, 2016; U.S. Department for Transport, 2016).

Hence, the current state of the technology, coupled with the expected improvements and plans already announced by several OEMs and other stakeholders, make it likely that fully AVs (levels 4 and 5 of automation) would be available by the mid-2020s (Anderson et al., 2016), however this can only be made possible by a multidisciplinary effort and a holistic view of this future business model and market reality.

2.2. Product-Service System (PSS)

As pointed out by Attias and Mira-Bonnardel (2016, p.69), the automotive industry is going through some radical changes, and it's been struggling to find the right positioning, in a sense that "while cooperation with traditional players is necessary, OEMs find themselves obliged to form alliances with new entrants, often far removed from their core business" such as Google, Uber, Apple among other tech-companies.

Being that said, the traditional business model of selling cars as products is losing ground to alternative forms of commerce. As pointed out by Johnson and Mena (2008) manufacturers are combining products and services in order to provide greater value to the customer and to facilitate longer more profitable business relationships.

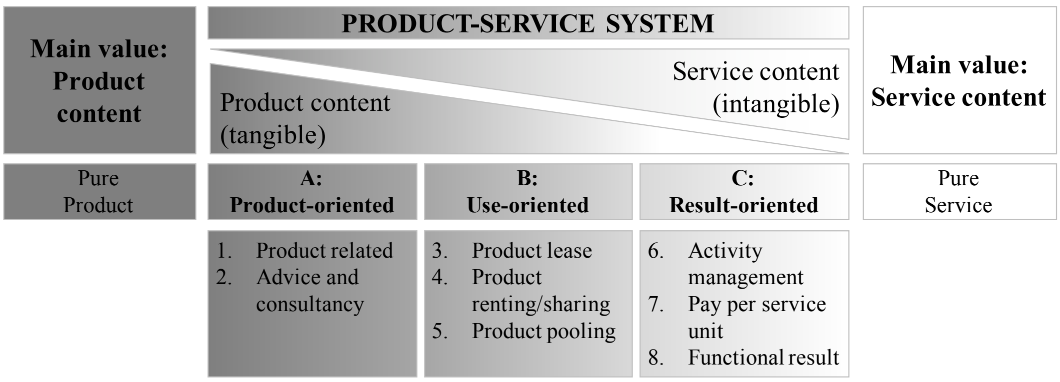
A Product-Service System (PSS) can be defined as consisting of tangible products and intangible services designed and combined with the aim of fulfilling users' needs or of a given function (Tukker, 2004; Poulain, 2017). In other words, PSS may be defined as a solution offered for sale that involves both a product and a service element, to deliver a required functionality (Wong, 2004).

In this sense, a business model in which cars are offered as services is gaining strength and it's being tackled by many companies and scholars. As Burns, Jordan and Scarborough (2013, p.101) stated: "an analysis by Larry Burns, the former Vice President of GM, estimates using a shared, self-driving, and purpose built fleet of vehicles could reduce the total cost of ownership from US$1.60 per mile down to US$0.50 per mile, this is more than a 10-fold improvement compared to personally owned vehicles".

"As a result, traditional players in the industry find themselves obliged to form new alliances with companies in emerging sectors (e.g. performance economy, circular economy, digital economy, etc.)" (Attias & Mira-Bonnardel, 2016, p. 72), therefore "an important part of the opportunities offered by PSS lies on the correlation between product and service activities" (Mahut et al. 2015).

Tukker (2004) drew a categorization of PSS by creating eight different types of Product-Service Systems, that according to the author exist with quite diverging economic and environmental characteristics. As displayed on Figure 1, it can be noted that types of PSSs vary on a spectrum in which on one end the main value rests on product content (tangible) and on the other on service content (intangible).

Figure 1. Categories of Product-Service Systems.



Source: adapted from Tukker (2004, p.248).

There are three main categories of PSS within the spectrum (Tukker, 2004, p.248):

A. **Product-oriented:** the business model is still mainly geared towards sales of products, but some extra services are added.
B. **Use-oriented:** the traditional product still plays a central role, but the business model is not geared towards selling products. The product stays in ownership with the provider, and is made available in a different form, and sometimes shared by a number of users.
C. **Result-oriented:** the client and provider in principle agree on a result, and there is no pre-determined product involved.

Within each main category, there are PSSs with quite different characteristics, and based on Tukker's (2004, p.248-249) framework AVs as a PSS are likely to be positioned on the middle category, that is, use-oriented PSSs in which according to the author is composed of three different PSSs:

- **Product lease:** The provider has ownership, and is also often responsible for maintenance, repair and control. The lessee pays a regular fee for the use of the product; in this case, normally he/she has unlimited and individual access to the leased product.
- **Product renting or sharing:** Here also, the product in general is owned by a provider, who is also responsible for maintenance, repair and control. The user pays for the use of the product. The main difference to product leasing is, however, that the user does not have unlimited and individual access; others can use the product at other times. The same product is sequentially used by different users.
- **Product pooling:** This greatly resembles product renting or sharing. However, here there is a simultaneous use of the product.

Nonetheless, AVs represent a potentially disruptive and beneficial change to the current road transportation system business model, since such vehicles could facilitate driving; increase road safety; reduce emissions of pollutants; reduce traffic jams; as well as could allow drivers to choose to do different things other than driving (Attias, 2016; Enoch, 2015; Schellekens, 2015; Schreurs & Steuwer, 2015). Thus, access to fully automated vehicles would also improve mobility for those who cannot or do not want to drive, hence, improving their quality of life (Attias, 2016; Poorsartep, 2014). As a result, AVs could provide significant economic, environmental and social benefits (Mutz et al., 2016; Fagnant & Kockelman, 2015; U.K. Department for Transport, 2015).

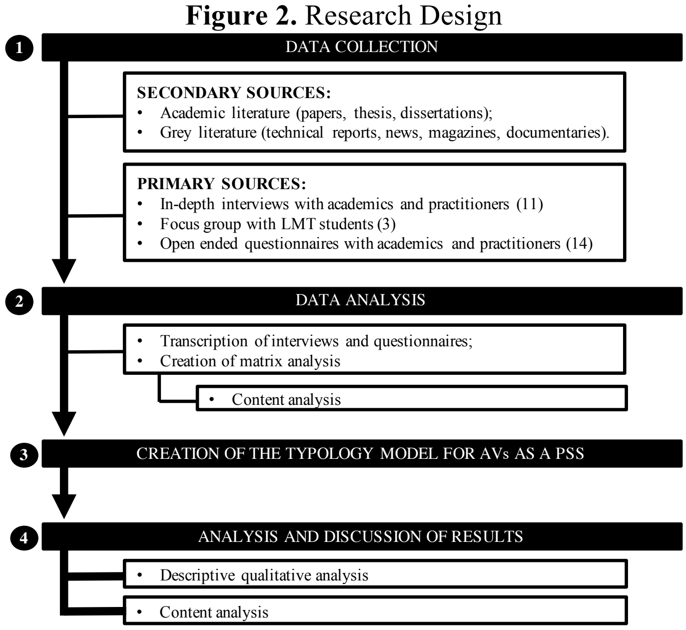
Therefore, such disruptive innovation (AVs as a PSS) represents a solution to an unmet need (Nogami & Veloso, 2017), since it represents an innovation in products, services, and business models that offer different solutions and alternatives to the market, and are mainly direted at non-traditional consumers, hence, it changes social practices and ways of living, working, and interacting (Christensen, 2001).

3. Methodology

Considering that this paper aimed at drawing a typology model for the uses of Autonomous Vehicles in the scope of a Product-Service System[1] by identifying their characteristics and key performance indicators, the adopted research design was characterized as a qualitative approach of exploratory-descriptive nature.

It is exploratory in a sense that studying AVs as a PSS is still little addressed in the business literature and thus, there is a lack of business-like academic knowledge regarding this object of study (Gandia et al., 2017; Cavazza et al., 2017), it is also descriptive because it aims at describing and analyzing phenomena (Malhotra, 2001; Gil, 2008). Figure 2, details the research design adopted in the research.

Figure 2. Research Design



Source: prepared by the authors.

In order to prepare the interview script and the questionnaires used in the primary data collection, we first resorted to accessing and reading secondary data, such as: technical reports from governments, car-manufacturers, consulting companies as well as academic literature on the field (journal and conference papers, thesis and dissertations).

After the gathering of secondary data, we were able to formulate the interview script and open ended questionnaire. Both instruments were submitted to pre-tests with professors and doctoral students

---

[1] It would be emphasized that in this paper we proposed to analyse the use of Autonomous Vehicles in public roads (highways, streets and avenues), not vehicles for warehouses, drones, etc.

from Ecolé CentraleSupeléc (Université Paris-Saclay, France) before conducting the primary data collection.

As for the in-depth interviews, we were able to reach 10 academics (being 7 professors; 1 post doc, 01 doctoral student and 1 master students); and 2 practitioners in France. We were also able to use the interview script to conduct a focus group with undergrad students from the Terrestrial Mobility Laboratory from Federal University of Lavras – Brazil. Regarding the open-ended questionnaires, from the interviewed actors and through the snowball technique (Atkinson & Flint, 2001), we sent the questionnaire via GoogleDocs to approximately 70 specialists (academics and/or practitioners involved with AVs research) and we had 14 responses, comprising in a response rate of 9,8%.

On stage 3, all interviews were transcribed and all questionnaires were tabulated, thus, generating a qualitative matrix for data analysis and categorization. At last, on stage 4, we used categorical content analysis (Bardin, 2010; Gil, 2008), for creating a set of qualitative categories of analysis in which some categories were previously established according to the aim of the paper and others were included and / or excluded during the analysis process.

After analyzing each category, we were able to create the different typologies for AVs as a PSS, emphasizing their main characteristics. Such results are presented and discussed as follows.

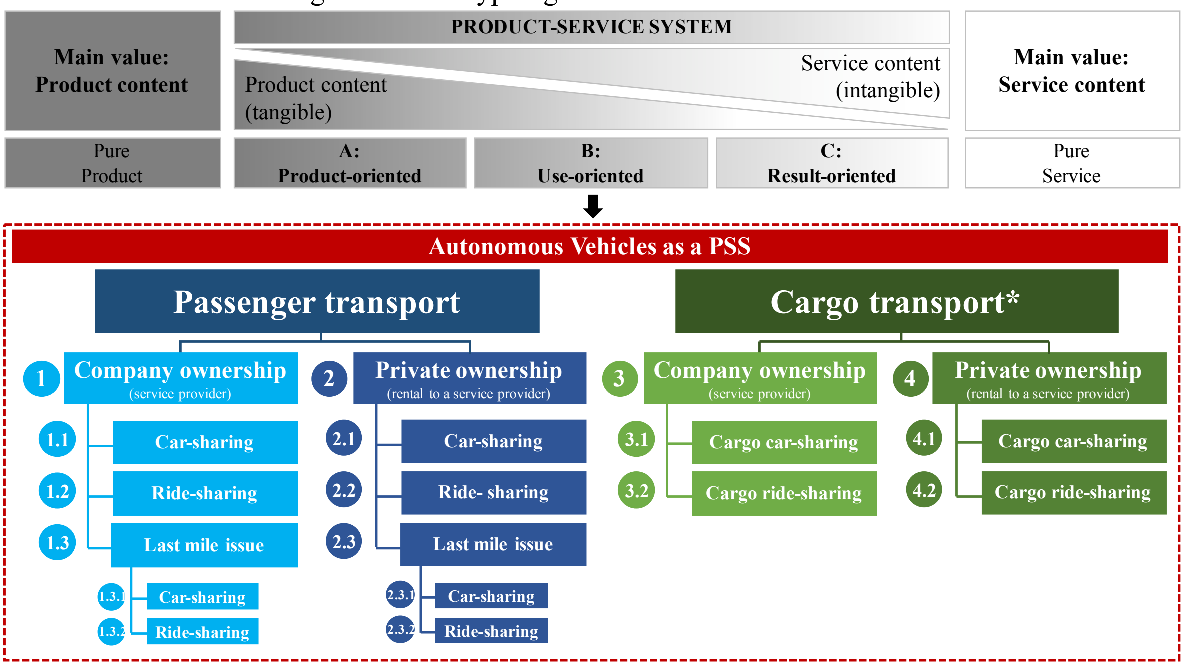
4. Results and discussion

Based on the research data, we present in this the typologies of uses for AVs as a PSS, explaining their main characteristics and peculiarities.

4.1. Typologies of uses for Autonomous Vehicles as a Product-Service System

Based on the categorical analysis of the interviews and questionnaires, we were able to draw a set of uses typologies for the Autonomous Vehicles as a Product-Service System. As detailed on Figure 3, AVs are better fitted on the “use oriented” category of Tukker’s (2004) PSS model, that is: the traditional product (Autonomous Vehicle) still plays a central role, however the business model is not geared towards sales, in this sense, the product is not in the possession of the service provider customer, instead it stays in the ownership of a service provider (or even other ownership forms), and is made available to the service provider’s consumers in different forms (typologies).

Figure 3. Main typologies of uses for AVs as a PSS.



** It is worth highlighting that the main focus given by the research participants was in the transport of passengers, however a couple of participants mentioned the cargo issue, therefore, for the sake of covering the largest array of typologies possible, we included the transport of cargo in the discussions.*

Source: prepared by the authors based on research data.

On Figure 4, two main set of uses typologies can be considered: transport of passengers (blue) and; transport of cargo (green), we were able to subdivide both into two main business models' types:

1) **Company ownership** – the service provider owns the fleet of vehicles and not only is in charge of managing the rides, the application and the algorithm of the service (a.k.a.: the platform), but also is responsible for all the costs of maintaining the fleet (insurance, maintenance, etc).
2) **Private ownership** – the service provider does not own the vehicles (such cars belong to ordinary people, who, when not using the vehicles can lease or rent them to the service provider that will further make such cars available to its clients), consequently the service provider does not have to bear all the costs of ownership and maintenance of the fleet, therefore is able to focus their efforts on managing the platform (rides, the application and the algorithm of the service).

Furthermore, for each type of the afore mentioned business models, we were able to further subdivide them into different typologies of uses. For the transport of passengers (both company and privately owned) we were able to extract three main typologies of uses (car-sharing; ride-sharing and; last mile issue) as for the transport of cargo (both company and privately owned as well) we were able to identify two main typologies (cargo car-sharing and cargo ride-sharing), which according to the research participants, would work similarly to the PSS businesses models for transporting passengers, but giving room for the transport of cargo instead. Their characteristics are better described as follows:

4.1.1. *Car-sharing*

Being able to exist in both passenger and cargo transport and in both ownership levels (company owned or privately owned), this typology, as known as "ride-hailing" or even "ride-booking", is consistent with the current premium services provided by companies such as Uber (Uber X) and Lyft (Plain Lyft), by offering an individual consumer service.

As pointed out by a Boston Consulting Group report in 2016:

> As with sharing a conventional car, sharing an AV will be substantially cheaper and less aggravating than owning a car in the traditional way: instead of bearing these burdens themselves, co-owners pay a membership fee to fleet service that provides management and maintenance services and makes sure that owners get the type of car they need for each trip. But door-to-door autonomous technology makes car sharing even more attractive, by eliminating or reducing several common barriers (BCG, 2016, p.5).

Therefore, in this typology, the user expects service exclusivity and does not mind paying more for it, in return values premium amenities within the vehicle (such as personalized infotainment options, drinks, snacks and etc.) as well as values the exact time of arrival at the destination, since there are no stops to pick up other passengers (which happens with the ride sharing typology).

4.1.2. *Ride-sharing*

Similarly, to car-sharing, this typology could also be present for both passenger and cargo transport in both company as well as private ownership forms. However differently, the ride-sharing typology is a synonym for carpooling, that is: sharing a ride with other passengers – similarly to services such as Uber Pool and Lyft Line.

The key-factor behind this typology is mainly price, that is, the client compromises on sharing the vehicle with other users and in return pays less for the ride. Infotainment options could also be available in this typology, however in a more limited setting when compared to the car-sharing business model.

4.1.3. *Last mile issue*

The last mile issue is a recurring problem is large cites and it encompasses the difficulty in getting people from a transportation hub (railway, metro or bus stations, and ferry slips), to their final destination. Such problem can also happen in the beginning of a journey – that is: the "first mile issue". This could be illustrated in the following passage;

> *"the autonomous car can let to use the time of the driver in whatever it want, and let to eliminate the last and first mile time (parking, checking security, pay services,...)"* (questionnaire respondent 4)

As pointed out by Scheltes and Correia (2017) the last mile in a public transport trip is known to bring a large disutility for passengers, because the conventional transport modes for this stage of the trip can, in many cases, be rather slow, inflexible and not provide a seamless experience to passengers. Therefore, according to the authors, AVs could act as a first mile/last mile connection to mass public transport modes.

In the present study, this typology (that was only mentioned by the research participants for the transport of passengers) can also be available as a company ownership or private ownership models, and it can be offered by consumers as a car-sharing as well a ride-sharing service.

It is worth mentioning that such typologies, discussed above, correspond to the seminal developments that can occur considering business models of 1) company ownership and 2) private ownership as a starting point. From these initial typologies several unfoldings can arise, as well as hybrid typologies according to the later advance and development of the AVs.

5. Concluding Remarks

By seeking to draw a typology model for the usages of Autonomous Vehicles in the scope of a Product-Service System, this paper aimed at identifying the largest possible array of uses typologies as well as the main key performance indicators.

We found that AVs as a PSS fit under the "user-oriented" category of Tukker's (2004) PSS model, that is, the service (transport of passengers and / or cargo) is offered by a provider via a product (autonomous vehicle) that can be owned by a company and or an individual.

As for the typologies, 2 main groups were identified: 1) transport of people and; 2) transport of cargo, and within each group two set of business models arose; a) a company-owned model – in which the service provider not only offers and manages the transportation service but also owns and maintains the fleet and; b) a privately-owned model in which the individual can offer the transportation service by him/herself or opt to rent his/her vehicle to a service provider to handle the transportation service. Furthermore, within each set of business model, three main sub typologies were identified: 1) car-sharing; 2) ride-sharing and 3) last mile issue – which can be further subdivided into car-sharing and ride-sharing as well.

As for research limitations, we point out the novelty of the theme, in a sense that since AVs are not yet a reality in the market, doing research on the topic is challenging due to lack of information as well as due to high speculations. Also noteworthy is the difficulty in obtaining answers to the questionnaires and contact of people involved in the industry, since discussions about AVs in the business environment are still mainly being kept confidential, therefore we were not able to get as many answers as we desired.

6. Bibliographical References

Anderson, J. M., Nidhi, K., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, O. A. (2016). *Autonomous vehicle technology: A guide for policymakers*. Santa Monica: Rand Corporation.

Atkinson, R., Flint, J. (2001). Accessing hidden and hard-to-reach populations: Snowball research strategies. *Social research update*, *33*(1), 1-4.

Attias, D. (2016). The Autonomous Car, a Disruptive Business Model? In: Attias, D. (2016). *The Automobile Revolution: Towards a New Electro-Mobility Paradigm.* (1st ed.). Gewerbestrasse (Switzerland): Springer International Publishing.

Attias, D., Mira-Bonnardel, S. (2016). Extending the Scope of Partnerships in the Automotive Industry Between Competition and Cooperaiton. In: Attias, D. (2016). *The Automobile Revolution: Towards* *a New Electro-Mobility Paradigm.* (1st ed.). Gewerbestrasse (Switzerland): Springer International Publishing.

Bardin, L. (2010). *Análise de conteúdo*. Lisbon (Portugal): Editora 70.

Boehm, M., O. Thomas (2013). Looking beyond the rim of one's teacup: A multidisciplinary literature review of Product-Service Systems in Information Systems, Business Management, and Engineering & Design. *Journal of Cleaner Production*, *51*(15), 245-260.

Boston Consulting Group. (2016). Will Autonomous Vehicles derail trains? Available at: <https://www.bcg.com/publications/2016/transportation-travel-tourism-automotive-will-autonomous-vehicles-derail-trains.aspx> Accessed in: October 17th, 2017.

Burns, L., Jordan, W. & Scarborough, B., (2013). *Transforming personal mobility*, Broadway NY: Columbia University.

Cavazza, B. H., Gandia, R. M., Antonialli, F., Nicolaï, I., Zambalde, A. L., Sugano, J. Y., Miranda Neto, A. (2017). Managment and Business of Autonomous Vehicles: a systematic integrative bibliographic review. *Proceedings of the European Conference on Innovation and Entrepreneurship*, [ECIE]. Paris, France, 12.

Chen, C. (2004). Searching for intellectual turning points: progressive knowledge visualization. *Proceedings of the National Academy of Science of the U.S.A.*, 101, 5303-5310.

Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology*, *57*(3), 359-377.

Christensen, C. M. (2001). The past and future of competitive advantage. *Sloan Management Review*, *42*(2), 105–109.

Dellios, K., Patsakis, C., & Polemi, D. (2016). Automobile 2.0: Reformulating the Automotive Platform as an IT System. *IT Professional*, *18*(5), 48-56.

Enoch, M. P. (2015). How a rapid modal convergence into a universal automated taxi service could be the future for local passenger transport. *Technology Analysis & Strategic Management*, *27*(8), 910-924.

Fagnant, D. J., Kockelman, K. (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Trasponrtation Research Part A: Policy and Practice*, *77*, 167-181.

Frazzoli, E., Dahleh, M. A., Feron, E. (2002). Real-time motion planning for agile autonomous vehicles. *Journal of Guidance, Control, and Dynamics*, *25*(1), 116-129.

Gandia, R. M., Antonialli, F., Cavaza, B. H., Miranda Neto, A., Lima, D. A., Sugano, J. Y., Zambalde, A. L., Nicolai, I. (2017). Autonomous vehicles: Scientometric and bibliometric studies. In: Gerpisa International Colloquium: R/Evolutions. New technologies and services in the automotive industry. Paris. 25.

Gil, A. C. (2008). *Como elaborar projetos de pesquisa*. (4th ed.), São Paulo (Brazil): Atlas.

Johnson, M., Mena, C. (2008). Supply Chain Management for Servitized Products: a multi-industry case study. *International Journal of Production Economics*, *114*(1), 27-39.

Kröger, F. (2015). Automated Driving in Its Social, Historical and Cultural Conxtexs. In: Maurer, M., Gerdes, J. C., Lenz, B., Winner, H. (2015). *Autonomous Driving: technical, legal and social aspects.* (1st ed.). Berlin: Springer Open.

Lima, D. A. (2015). *Sensor-based navigation applied to intelligent electric vehicles.* Doctoral thesis, Universit De Technologie De Compi gne, Compiègne, France.

Mahut, F., Daaboul, J., Bricogne, M., & Eynard, B., (2015). Survey on product-service system applications in the automotive industry. *IFAC-PapersOnLine*, *48*(3), 840–847.

Malhotra, N. (2001). *Pesquisa de marketing*: uma orientação aplicada. (3rd ed.), Porto Alegre (Brazil): Bookman.

Manzini, E., Vezzoli, C. (2003). A strategic design approach to develop sustainable product service systems: examples taken from the 'environmentally friendly innovation'Italian prize. *Journal of cleaner production*, *11*(8), 851-857.

McKinsey & Company. (2016). An integrated perspective on the future of mobility. Available at: <https://data.bloomberglp.com/bnef/sites/14/2016/10/BNEF_McKinsey_The-Future-of-Mobility_11-10-16.pdf> Accessed in: October 17th, 2017.

Mutz, F., Veronese, L. P., Oliveira-Santos, T., de Aguiar, E., Cheein, F. A. A., & De Souza, A. F. (2016). Large-scale mapping in complex field scenarios using an autonomous car. *Expert Systems with Applications*, *46*, 439-462.

Nogami, V. K. C., Veloso, A. R. (2017). Disruptive innovation in low-income contexts: challenges and state-of-the-art national research in marketing. *RAI Revista de Administração e Inovação*, *14*(2), 162-167.

Poorsartep, M. (2014). Self-Driving Cars: Radical Innovation in the Transportation Industry. In: Christiansen, B., Yildiz, S., Yildiz, E. (2014). *Transcultural Marketing for Incremental and Radical Innovation.* (1st ed.). Hersey (Pennsylvania): IGIGlobal.

Poulain, B. (2017). State-of-the-art: Product and service systems modelling [Working Paper Nº 01]. *École Centrale Paris*, Châtenay-Malabry, France.

Reschka, A. (2015). Safety Concept for Autonomous Vehicles. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H. (Eds.) (2015). *Autonomous Driving: technical, legal and social aspects*. Berlin: Springer. pp.473-496.

SAE International. (2016). Surface vehicle recommended practice: (R*) Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles.* USA.

Schellekens, M. (2015). Self-driving cars and the chilling effect of liability law. *Computer Law & Security Review*, *31*(4), 506-517.

Scheltes, A., Correia, G. H. A. (2017). Exploring the use of automated vehicles as last mile connection of train trips through an agent-based simulation model: An application to Delft, Netherlands. *International Journal of Transportation Science and Technology*, *6*(1), 28-41.

Schoitsch, E. (2016). Autonomous Vehicles and Automated Driving Status, Perspectives and Societal Impact. Information Technology, Society and Economy Strategic Cross-Influences (IDIMT-2016). *24th Interdisciplinary Information Management Talks, 45(1),* 405-424.

Schreurs, M. A., Steuwer, S. D., (2015). Autonomous Driving – Political, Legal, Social, and Sustainability Dimensions. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H. (Eds.) (2015). *Autonomous Driving: technical, legal and social aspects*. Berlin: Springer. pp. 149–171.

Tukker, A. (2004). Eight types of product– service system: eight ways to sustainability? Experiences from suspronet. *Business Strategy and the Environment*, *13*, 246-260.

U.K. Department for Transport. (2015). *The Pathway to Driverless Cars: a detailed review of regulations for automated vehicles technologies.* U.K. Government. Available at: <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401565/pathway-driverless-cars-main.pdf> Access in: February 23rd, 2017.

U.S. Department of Transportation. (2016). F*ederal Automated Vehicles Policy: Accelarating the next revolution in roadway safety.* Available at: <https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf> Access in: January 2nd, 2017.

Weick, C. W., Jain, R. K. (2014). Rethinking industrial research, development and innovation in the 21st century. *Technology in Society*, *39*, 119-116.

Wong, M. T. N. (2004). Implementation of innovative product service systems in the consumer goods industry. Doctoral dissertation, University of Cambridge, Cambridge, United Kingdom.