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# Car Sharing Service Innovation: A New Concept for the Inclusion of Wheelchair Users

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## Abstract

Taking the huge role of services in the world economy today, the growing number of people with disabilities in the world, and the lack of transport solutions for their social inclusion, this paper presents the service development process of a conceptual Assistive Technology solution for wheelchair users. The method adopted in this research was a reference model for the systematic New Service Development, composed of macro phases, phases, activities and tasks. This paper presents the main results of the conceptual design phase, where the main innovations occur, what characterizes the value creation of the service, and that is the reason why it was chosen as a scope delimitation of this paper.

***Index terms***— new service development, assistive technology, transport, wheelchair user.

## 1 Introduction

ore than one billion people worldwide live with a disability, according to the World Report on Disability, published in 2011 by the World Health Organization and World Bank (1). In the U.S., a nation of over 290 million, the U.S. Bureau of Transportation Statistics (2) survey found that almost 15 million people have difficulties getting the transportation they need. Of these, about 6 million (40 percent) are People with Disabilities (PwD) and about 560,000 of them indicate they never leave home because of transportation difficulties.

For all individuals, including those who have disabilities and those who are elderly, transportation is an important component to full integration into the community (3) enabling access to employment, socialization, health services, and the operation of households and businesses (4).

A study by Gray et al. (5) indicates that transportation is a key barrier to community participation among individuals who have disabilities. In a study in Europe, the transport was a frequently cited obstacle to the involvement of PwD (6). The lack of public transportation is itself a main barrier to access, even in some highly developed countries (7).Also, in other surveys like NTIS (8) in the USA, Baudoin et al. (9) in France and Mashiri et al. (10) in the developing world, the results, according to Zhou et al. (11), show that to improve the quality of life for PwD, both developed countries and developing countries need to improve the accessibility of the urban public transportation and to make it more attractive.

Although many publications concerning transport solutions refers to public transportation, Finn (12) states that car is currently the dominant mode of passenger transport in developed countries and conventional passenger transport cannot achieve significant further mode shift from a car for the simple reasons that many of the trips made by car are not suited to the common public transport services. Many car users have such negative opinions of public transport that they are highly resistant.

To avoid problems arising from the growth of private car ownership, like road congestion, tough parking, air pollution, and other severe issues, car sharing has been an innovative transportation utilization. The development policy of car sharing and its benefits in social, traffic, energy and environment is worthy of research (13).

In Brazil, the number of PwD is not different from the world's tendency. According to the last census of the Brazilian Institute of Geography and Statistics (14), about 46 million Brazilians, 24% of the total population, have some kind of disability. Adding to this number yet other people with reduced mobility, whether permanent or temporary, like pregnant, infants and other people with reduced mobility, it is approximately 43.5% of the population. Finally, by being involved relatives and other people in their care and monitoring, the amount can exceed 70% (15).

Santa Catarina, located in the south of Brazil, follows the national average of PwD, with 21.3% (14). Concerning the urban mobility, Medeiros (16) identified Florianópolis, the capital of Santa Catarina, as the second-worst record in the world and the first among 21 major Brazilian capitals. He suggests in his research to promote integration between various modes of transport, to alleviate the problem.

The knowledge area engaged with solutions for PwD is called Assistive Technology (AT), defined by **??**ook and Hussey (17) as a broad range of devices, technical aids, strategies, services, practices, with the main objective of improving the quality of life of the disabled and the elderly. Other definitions, like Azevedo et al. (18), focus the aim of AT in reducing dependence on others and contributing to the integration into the families and society. Consistent with this approach is the relational definition of autonomy as the ability to plan one's own life, to enter into relation with the others and, together with them, to actively participate in the construction of society (19).

Although the definition of AT refers not only to the product but also to service, only a few publications have been found relating to New Service Development (NSD) and AT. Many of them refer to adaptive service, like Wilder et al. (20), that develops a conceptual framework to understand which frontline employee actions need to be encouraged to increase the ability to provide an adaptive service offering. And not to a complete new development oriented to the PwD. Taking the huge role of services in the world economy today, the growing number of PwD in the world, and the lack of transport solutions for their social inclusion, this paper presents the service development process of a conceptual solution for the individual and autonomous shared transport of wheelchair users. It was developed through the Service, Process and Product Engineering Group of the Federal University of Santa Catarina, located in Florianópolis, and for this reason, took some examples of this city. But the concept presented is universal and can be applied as a transport solution in any place.

# 2 II.

# 3 Transport for Wheelchair Users

To get understand of the problem, the literature review started with a general overview about transportations possibilities for wheelchair users, following with an exhaustive review on databases, looking for relevant studies related to the proposal of this paper. It concluded with a search on the web, presenting existing services possibilities for wheelchair users.

The first step for a literature review of existing studies concerning transport for PwD was the definition of the strings for the search on databases. For getting a general overview, it was analyzed terms like Demand-Responsive Transport (DRT), Flexible Transport Services (FTS), Flexible Urban Transport (FUT), Intelligent Transport Systems (ITS), Special Transport Services (STS), Handicap Transport and Paratransit.

According to **??**ulley and Nelson (21), DRT has been increasingly applied in the last ten years to a niche market that replaces or feeds conventional transport where demand is low and often spread over a large area. More recently, the concept of DRT as a niche market has been broadened to include a broader range of flexible, DRT services and is increasingly referred to as FTS.

FTS was defined by Mulley et al. (22) as a transport service where at least one of the characteristics (route, vehicle, schedule, passenger and payment system) is not fixed. In the public transport context, this contrasts with the service which has a fixed route, fixed timetable and fare, and vehicles with drivers scheduled on a regular basis.

Similarly, Finn (12) defined FUT as a range of mobility services that are collective in offer and have greater flexibility in route and timing than regular public transport services (e.g., bus, metro), including DRT operated by buses, mini busses or microbuses, shared taxis (sometimes known as taxi-buses), dynamic carpooling, employee commuter programs, car-sharing and dedicated services for people with reduced mobility or other needs.

While the economic and efficiency benefits of ITS are well established, the goal of many research concerning this term have been about environmental impacts, like to demonstrate the simultaneous propensity for low carbon benefits through the deployment of ITS (23) or the development of performance criteria that reflect the contributions of Information Communication Technology (ICT) emissions, vehicle emissions and the embedded carbon within the physical transport infrastructure that typically comprises one type of ITS (24).

By STS, defined as a special transport for disabled people unable to use regular public transport (25), the dominant solution is the door-to-door demandresponsive taxi trip. Most trips involving wheelchair users are made with STS special vehicles, e.g. converted minivans or vans (26).

STS door-to-door solution is also classified as a DRT (21), usually for disabled and elderly. Interested users would telephone in their requests some days before they intended to travel and, the operator would plan the service manually the day before the trip. Biering-Sørensen et al. (27) mentioned Handicap Transport as particular arrangements with a public or private passenger transportation service, which is most often transportation in (mini) bus, but also special service in using trains.

Paratransit was already a relevant study in the 70's, when Roos and Alschuler (28) described it as personalized public transportation by responding to the needs of individual markets and users, bridging the gap between static fixed-route transit and the flexible automobile travel. Fu (29) affirms that the major role of a scheduling system is to determine the pickup and dropoff routes and times for a fleet of vehicles carrying customers between speci fied origins and destinations. Also, there are problems like high fees, difficulty in scheduling and long waiting

periods, and for these reasons it has been blamed for causing disorder in the traffic system, posing it with the problem of being confronted with pressures to eliminate it rather than to try to improve it (30). **??**uning et al. (31) demonstrated the preference for fixed-route over Paratransit through a web-based survey with a total of 283 wheelchair-seated bus riders, investigating their experiences on public fixed-route buses.

This overview with the common terms related to the transportation of PwD shows that they are many times used as synonymous and, according to Mulley and Nelson (21), these traditional services have often been criticized because of their relatively high cost of provision, their lack of flexibility in route planning and their inability to manage high demand. Further, there were not identified papers about individual and autonomous shared transport for wheelchair users, which conducted this search for information to a systematic literature review.

The second step on the search for information was a systematic literature review on Web of Science (WoS) and Scopus, the two most extensive databases for literature searches (32). The key words used for the literature review were divided into four groups, aiming to identify documents related to i) transport mode (individual or personal and not public); ii) independent AT (autonomous or independent); iii) transportation possibilities related to PwD and iv) market segment (wheelchair users). The search string used these words and their synonymous, resulting in 35 documents on Scopus and 18 on WoS. Joining them into a reference management software and deleting the duplicates, resulting in 39 documents.

The results were grouped into four categories and subdivided into subgroups. Most articles referred to mobility, like the use of AT devices, describing their development or tests; some papers were related to specific topics about medicine and others to areas of AT unrelated to transport. Even among essays related to transport, there was no study concerning new service for the transportation of wheelchair user, which emphasizes the innovation of the service proposed in the current paper.

The search for information on the web resulted on Table 1, describing some existing transport services for the wheelchair user, and on Figure 1, illustrating three examples of products available for wheelchair users as driver remaining seated in their wheelchairs: i) one place car, ii) up to three places for wheelchair users and iii) motorcycle. Concluding the literature review, there was found no service offering for the individual and autonomous shared transport of wheelchair users, which states the originality of the current proposals.

# 4 III.

# 5 Methodology

A reference model was adopted as methodology for this research. For Chimendes et al. (33), the main goals of a reference model are to minimize three problems related to services development process: i) the lack of systematic approach, ii) the absence of documents and records that assure the control of the services development description, and iii) the absence of tests documentation for the verification and validation of the developed service. According to Fitzsimmons and Fitzsimmons (34), the development of a new service based on subjective ideas contained in its concept can lead to very costly efforts of trial and error to turn this concept into reality. NSD refers to the overall process of developing new service offerings (35), from idea generation to launch or implementation (36).

For Ordanini et al. (37), empirical evidence about the impact of innovativeness on new service adoption is inconclusive because service innovation has far been studied using new product frameworks that do not fully capture the complexity of new service assessments by customers. The method adopted in this research was the reference model for a systematic NSD process presented by Forcellini (38). Based on Stanke (39), the first two stages refer to value identification, the next two stages to value proposal, and last stage to value delivery. It is composed of macro phases, phases, activities and tasks, covering from strategic planning up to launching and monitoring the market of the service.

This model deals with the service as a system, forming a whole, where the subsystems must function separately but also together with other subsystems, which consist of customers, organization structure and system, management and staff, and physical and technical resources.

It should consider an interactive part, which is visible to the customer, support or back-office part, which is invisible to the customer, effects of the business concept, the strategy, and the goals of the company, and further, the service system can be affected by the internal infrastructure in the form of resources and competence in other parts of the company and the external infrastructure in the form of laws and regulations, etc. (40).

This paper presents the main results of the conceptual design phase of the reference model. In this phase occur the main innovations, which characterizes the value creation of the service, and that is the reason why it was chosen as a scope delimitation of this paper. The application of the conceptual phase allowed capturing the service requirements that were used as a starting point for creating a service concept.

IV.

# 6 Results

The main result of this research was a conceptual design of the service. It is characterized by using abstraction by identifying solutions, avoiding thus a common mistake among designers, of having a solution in mind that they would take to resolve a problem immaturely. This can often limit creativity during the service development process.

## 6 RESULTS

The three tasks needed to define the service design specifications were: i) identifying customer needs, ii) defining service requirements, and iii) defining service specifications. The next activity, developing alternative solutions for the service, is composed of two tasks: i) modeling the service functionally, and ii) generating service alternatives. Finally, the last activity, defining the service concept, consists of four tasks to assess the technical and economic criteria of the service alternatives: i) feasibility judgment, ii) technological availability, iii) go/ no go test, and iv) Pugh selection matrix.

The target audience of the proposed service is wheelchair users of both genders, with over 18 years of age, with upper limb mobility and without cognitive impairment. To identify their needs, the first task of this activity, a questionnaire was developed, based on the definition of service package of Fitzsimmons and Fitzsimmons (34), consisting of a) Supporting Facility (the physical resources that must be in place before a service can be sold); b) Facilitating Goods (the material consumed by the buyer or items provided by the consumer); c) Information (operations data or information that is provided by the customer to enable efficient and customized service); d) Explicit Services (benefits readily observable by the senses; the essential or intrinsic features; and e) Implicit Services (psychological benefits or extrinsic features which the consumer may sense only vaguely).

In total, 21 participants completed the questionnaire, of which 86.0% [18] was male, and 14.0% [3] were female. Reasons why people used a wheelchair were: disability by birth (33.4%), car accident (23.8%), polio (14.2%), cerebral palsy (9.5%), syringomyelia (4.8%) or others reasons (14.2%). Results further indicated that only 18.0% of respondents need help with some or all activities of daily living, while 82.0% can do it by themselves. Regarding the service proposed, 60.0% of respondents have qualified prone for carsharing, a significant number that justifies the development of the service, and when it presented the idea of service to a wheelchair user, 67.0% of them found the concept great. The customer needs expressed by the open-ended questions highlighted the lack of solutions, once they stated that "there is a lack of adequate transportation to travel and also generally in places of leisure and sport the architectural spaces are not accessible" and "access to these places are too precarious to go by wheelchair, and it is bad to transfer me from the wheelchair to the car". It was also clear the need of autonomy, because they said that they "usually go to places alone and just need someone to take the wheelchair out of the trunk", "it is very complicated to ask for help because there are few volunteer" and "freedom is so much desire". And some voices also claimed for new research, when they said that "some things can facilitate our lives, giving us the independence to come and go with our own resources". For the second task, the service requirements were obtained considering the customer need and also the service package of Fitzsimmons and Fitzsimmons (34). Through the application of the House of Quality matrix from QFD (Quality Function Deployment) method, the main steps of this task were: the establishment of customer needs importance degree through the Mudge Diagram, competitor's analysis, comparative analysis among service requirements through QFD Roof, the establishment of relationships among customer needs and service requirements and, as a result, the rank of service requirements.

As examples of competitors, only those who also promote transport without need of transfer from a wheelchair, two existing services in Florianópolis were considered. First, Urban Public Transport, despite the low price, has little flexibility in schedule and route. According to the information collected through the questionnaire, wheelchair users feel complicated to use the ramp, which in many cases does not work appropriately and the bus drivers do not pay enough attention to the user. The second example emerged in Florianópolis in 2013, is a van rental available to wheelchair users as passengers that can also offer a driver and up to two accompanyings. The price of this service, however, is high, there is the need for scheduling, and there is only one vehicle available in the city.

The last task, defining service specifications, consisted of a rank of service requirements (output of preview task), target value, undesirable aspects, and comments (when applied) of each requirement. This list was the output of this activity and guided all subsequent development of the service to design it according to customer needs.

The functional model of the service, the first task of this activity, was obtained through the analysis technique of functional decomposition, the process of starting at a high level and dividing entities into smaller and smaller related parts, that can be more easily understood (41) resulting in a textual description of functions and sub-functions.

To do the second task, generating service alternatives, it was first necessary obtaining principles of solutions for each sub-function, through methods of creativity like brainstorming, literature review, analysis of existing systems, analogy, synergy and others, culminating in a structured and systematic presentation of the principles of the solution on the Morphological Matrix.

The principles of the solution of sub-functions were combined to comply with the functions, generating service alternatives. Since the combination of all the principles of solution would lead to the development of a great number of alternatives, it was considered some criteria determining the number of combinations generated, like meet the design specifications, budget constraints, technological feasibility and common sense (42).

Fourteen alternatives were generated and the following example presents one of them: the company takes the vehicle to the customer after registration approval and customer returns vehicle anywhere; client becomes aware of the contract and sends copies of personal documents via web; company verifies documents for approval of registration and send per email confirmation; the client pays a membership fee and is enabled to use the service; the client requests the delivery of the vehicle and waits; upon reaching the vehicle, client releases it, checks it and drives it; in return, client checks out, closes vehicle, finishes reservation and pays the hours of use.

Defining the service concept consists of a sequence of four tasks to assess technical and economic criteria of the fourteen service alternatives i) feasibility judgment, ii) technological availability, iii) go/ no go test and iv) Pugh selection matrix.

The feasibility judgment was based on the experience of experts to determine whether an alternative is feasible or not, classifying them as i) Feasible (technologically and economically feasible); ii) Conditionally feasible (conditioned to verification of some remaining aspects); and iii) Not feasible (there are problems of conception or costs which unfeasible the alternative). Based on these criteria, seven alternatives were not feasible and were eliminated.

The technological availability examined whether a particular principle of the solution adopted technologies that are not yet available or are under development. Therefore, Forcellini (38) proposed questions so that a Yes answer (Y) has positive connotations and a No answer (N) a negative connotation in the evaluation. The results of this task, in which two more alternatives were eliminated, based on the good sense of the project team since they had some negative responses to the questions.

The Go/ Do not go test compared each alternative with the customer's needs. If the alternative did not attend the need, it became a N (Do not go), but in this stage, no alternatives were eliminated, since although some of them had five or six N, only one was related to the five more relevant customer's needs, according to the importance degree obtained through the Mudge Diagram.

The last task of this activity, Pugh selection matrix, compared relatively the alternatives, differing from the previous three tasks, whose evaluation form was absolute. Starting with a reference, chosen by the project team as the most promising alternative, each customer´s need was evaluated comparatively between this reference and the other alternatives. The next phase of the project will support the team with more information, which, together with these strategic decisions, will guide the team at the time of service launching to the market.

Meanwhile, the concept chose to follow the service development process was defined as follows: the client becomes aware of the contract, the terms and conditions and, fills his registration in the enterprise website. Copies of the client´s personal documents are sent per email. Verification of documents is done and a notification of approval is sent to the client. At this time, the client pays the membership fee and is enabled to use the service. The customer goes to the service, releases the vehicle, checks it, and drives it. In return, the client checks out, closes the vehicle, finishes reservation, and pays the hours of use. If the customer needs help at the station, it will receive help from an employee during this process.

V.

# 7 Evaluation of the Results

Aiming to the future implementation of this service, the conceptual design service proposed was evaluated through two techniques: storyboarding (Figure 2) and video sketching. Since there was already a result in a conceptual model (textual) service, the service prototyping, culminated in a graphical model, developed to identify and define the main processes and their activities needed to implementation, delivery and maintenance of the service.

This process and its results are perceived by the customer, whose satisfaction is affected by many aspects of the service organization. Thus, the service prototyping must involve the most significant activities in the evaluation of quality (43). So, this evaluation is never exhausted, and even when the service begins operation, system modifications are introduced as the conditions justify (34).

Service prototyping is a tool to test the service interaction with the user, presenting description and visualization aspects such as user experience, interaction modes, choices, and service organization. According to Meroni and Sangiorgi (44), it allows trying new services models, reducing the number of failures, and increasing the possibility of generating a more significant and desirable service. Storyboarding is intended to represent cases of use through a series of drawings or figures brought together in a narrative sequence. Its description starts with the client becoming aware of the contract [1] at the website of FFCCar, fictitious company name, in his home, or any other place outside the company and makes his online registration **??**2]. The company processes the information [3], checks the documentation [4] and if everything is conformed, sends a notification [5] of registration approved via email or phone to the customer to pay the membership fee [6], which will be converted into a bonus for using the service. It enables the client to use the vehicles [7].

To ensure availability, it is recommended that the client make a prior reservation [8] through the website or by phone. But if he prefers, he can go directly to one of FFCCar various stations [9] around the city and check availability directly at the self-service terminal.

If the consumer needs help, one of the employees can assist the customer by phone or even going to FFCCar station. If a vehicle that the customer wants is not available where he wants, he can contact the company that will try to relocate the vehicle from one point to another. Or, if the customer changes his mind when selecting the vehicle at the terminal, he can change the reservation. After choosing [10], the client must enter the password in the self-service terminal to open and release the vehicle [11]. It is necessary for the client to check the conditions of the vehicle [12] such as fuel quantity predetermined by the company, the presence of the key in the glove box, the cleaning and, then, afterward, he can drive the vehicle [13]. Since not all the city places are properly accessible for wheelchair users, the customer can choose one of the places listed in the accessible maps of the city and the partners of attention to accessibility, both provided by the company. When the reservation is coming to an end, the vehicle must be returned in the same place where it was taken, should also be checked [14] if it is in

the same condition in which it was before. If so, the client should stop the car, lock it [15] and pay [16] for the service in the selfservice terminal. Thus, the vehicle is released to another person's use.

To better understanding the Storyboard, a Video Sketching was used to produce a quick and valuable tool to simulate customers' participation and their involvement in the value production process, providing the design teams with a vision of how the design solution would behave. Creating scenarios as a video is an attractive way to prototype intangible experiences or services. The Video Sketching is available at the following address: http://www.youtube.com/watch? v=Ogod5Jsk-Z0 VI.

# 8 Conclusions

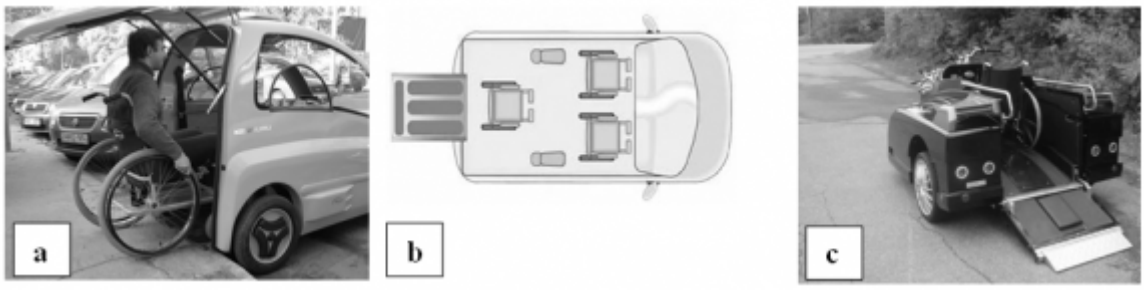
This paper presented an innovative conceptual proposal of service for individual and autonomous shared transport for wheelchair users, starting on customer needs and finishing on the process design service. A systematic literature review showed the originality of the new concept generated.

Developing a new service is not a simple task due their intangibility characteristics and all stakeholders involved since the strategic planning until the launching and monitoring market of the service. For this reason, it is very significant following clearly defined phases, activities, and tasks, of a structured method, dealing with service as a complex system, avoiding rework during the development, lack of multifaceted consideration of factors involved in the hole process and failure after launching the service. The reference model adopted allowed at first a better understanding of the problem through the identification of customer needs and their evolution to the service requirements, guiding the alternatives services generated, their evaluation and finally, the modeling and prototyping of the final concept.

Due to intangibility of services, information are considered basis for solutions, and the added value, since the customer needs until the process design service proposal, presented in this paper, can be the start point for investment by government and private investors, creating a business model addressing the real need of social and professional isolation of people who use a wheelchair.

The paradigm shift of dealing with AT as an investment and not an expense, treating the PwD with attention and not worry, is the first step on the way of pursuing diversity in the society, providing the experience for wheelchair users of freedom to leave home spontaneously, without having to rely on friends, family or the lack of flexibility of existing transportation services when they need to run errands, meet appointments or visit friends.

Researchers have a key role in this process, since seeking perfection in your results, supported by a scientific method, like the reference model presented in this paper. Technological advances aim to contribute to the pursuit of a society increasingly inclusive, and after so many revolutions which humanity has passed, might someday reach a human revolution, with citizens, with or without disabilities, living in conditions of equality. [1]




1

Figure 1: Figure 1 :

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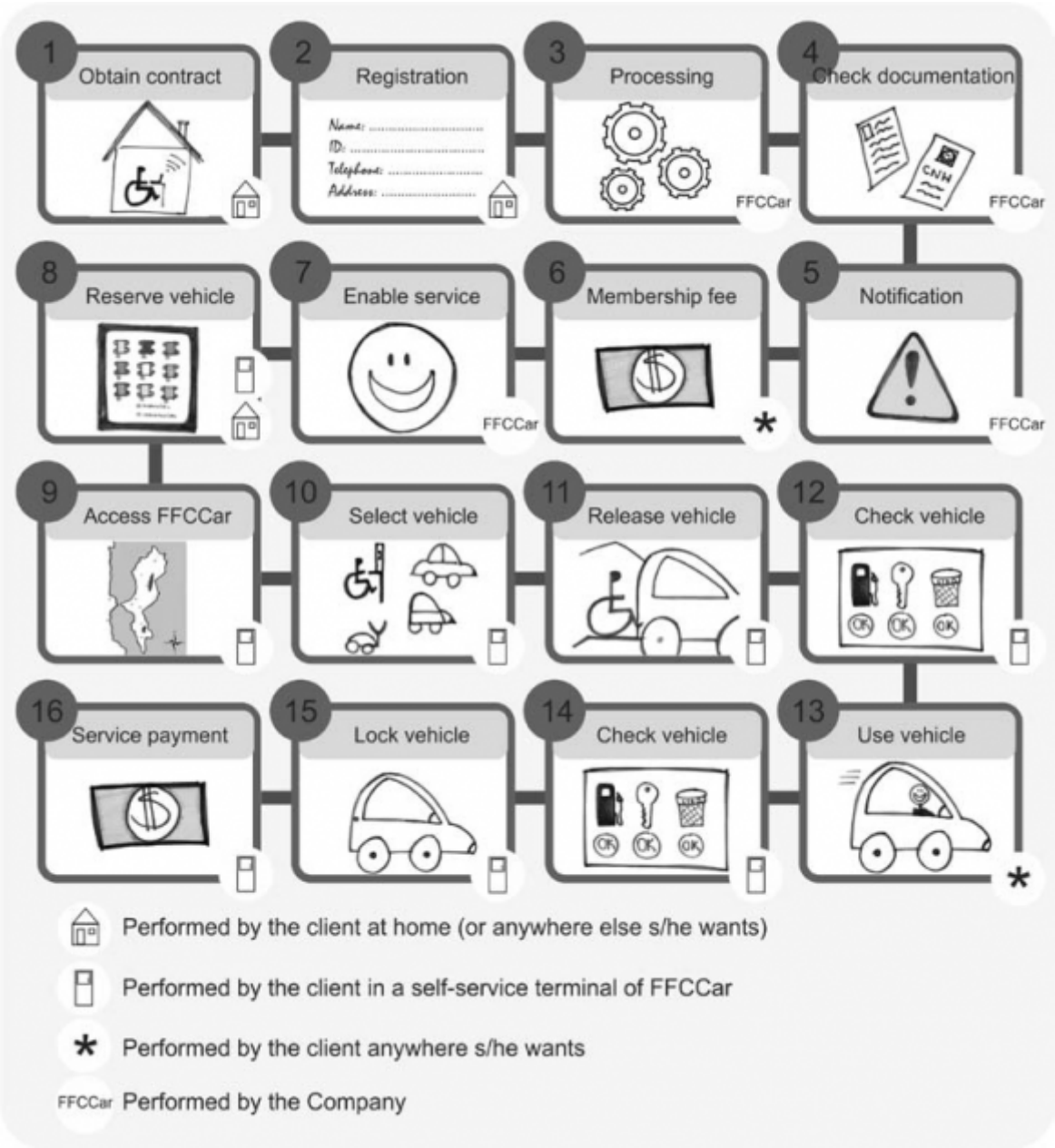


**2**

Figure 2: Figure 2 :

**1**

| Service | Characteristics | Site |
|---|---|---|
| Carsharing, which wheelchair users need a driver | Car is not equipped with hand controls or other driver adaption. | https://www.citycarshare.or |
| Carsharing of mobility device equipped vehicles | Provision of a range of mobility devices for customers with disabilities at no additional charge. It does not offer lift-equipped vans for rental. It requires one or two days to install the devices. | http://www.enterprisecarsha |
| Wheelchair accessible vehicles available to buy or rent, for or driver wheelchair user as passenger | There is only one vehicle model available for wheelchair user as a regional service centers door or collected from one of the driver; vehicle delivered direct to the | http://www.alliedmobility.co |
| Wheelchair van rental | Vans are modified according to the recommendations and guidelines of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and the National Mobility Equipment Dealers Association (NMEDA) | http://www.wheelchairgetaw |
| Wheelchair Accessible Taxi (WAT) | The introduction WAT into Tasmania is linked to the Commonwealth Disability Discrimination Act 1992 (DDA), aiming to eliminate discrimination | |

*[Note: http://www.transport.tas.gov.au Wheelchair Accessible Vans Provides a limited amount of free van vouchers exclusively to wheelchair users http://www.ci.berkeley.ca.us]*

Figure 3: Table 1 :

[Cooper et al.] , R G Cooper , C J Easingwood , S Edgett , E J Kleinschmidt , , C Storey . (What distinguishes the)

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