Fundamental and Key Concerns of the Shared Use Vehicle System

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Abstract – Currently, a significant portion of Shared-Use Vehicle Systems (SUVS) providers make use of cutting-edge technologies (such as GPS monitoring, smartcard access and online reservation systems) to improve customer experiences. There is a growing need for interoperability between vehicle operators and suppliers of Shared-Use Vehicle Systems (SUVS) (e.g., smartcard accessibility across different car-sharing businesses) (i.e., transport fare collection via smartcards). Improved interoperability across systems is expected to increase customer satisfaction and adoption, which in turn will expand the market reach of such systems. In a similar perspective, we might expect to see some uniformity develop in areas such as vehicle interfaces, client contacts, and general operating procedures (for example, online reservation systems and insurance policies). However, the idea of SUVS is still in its infancy as a mobility option, therefore a comprehensive push toward standardization has not yet been implemented in the sector. In that case, the purpose of this research is to attempt to catalog a few of the key concerns that will be crucial to future interoperability conversations between SUVS and the establishment of industrial standards. This paper focuses on the fundamentals of operating an intelligent SUVS and details many of the concerns that have arisen throughout the formative stages of SUVS development.

Keywords – Shared Use Vehicle Systems (SUVS), Intelligent Transportation System (ITS), Vehicle Access Control (VAC).

I. INTRODUCTION

There has been a lot of interest and action in Shared-Use Vehicle Systems (SUVS) since they represent a novel approach to transportation. In the case of SUVS, such as car-sharing or station cars, a fleet of vehicles is utilized by many people on a daily basis. Car sharing offers the flexibility of a private vehicle together with the convenience of public transportation, as opposed to riding the bus or train wherever people go. This form of improved administration and service to users has resulted from the incorporation of various levels of Intelligent Transportation System (ITS) technology into widely utilized systems in recent years. Over these years, the concept of SUVS has gained a lot of traction as a viably new way to render transportation benefits. By utilizing a fleet of shared vehicles (including automobiles, bikes, and scooters) as required, rather than relying on one's own automobile, the fundamental idea behind SUVS is to reduce reliance on private automobile ownership. Better vehicle usage (and hence increased transportation efficiency), user cost savings, emission/energy benefits, and developed accessibility to the present transit operations are only some of the inherent benefits of SUVS.

Kek, Cheu, and Chor [1] provide a further discussion of the benefits of SUVS. From the research, it is noted that numerous shared-use car services have emerged over the last few years, each catering to a unique business model (or market sector) and set of needs. In 2002, a framework was devised to classify several types of SUVS, such as neighborhood carsharing and station car systems. Understanding what characteristics characterize such classification frameworks is a prerequisite to developing one. In **Table 1**, different components that characterize the classification systems of SUVS have been presented. With these components, European countries and commercial shared-use services in the United States are able to establish a framework to operate effectively.

Table 1. Components of the Classification Framework of SUVS

Definition of Basic Objectives	The goals of the system might vary depending on whether it is a scholarly experiment, a for-profit local organization, an internal corporate initiative, or a franchise.
Links with Other Travel Modes	Connectivity to other transportation networks, such as bus and train systems, is an important aspect of shared-use car services.
Size of Target Area and Target Group Served	Mobility Carsharing in Germany, Italy and Switzerland are just a few examples of the kinds of international markets that are being pursued.
Organization, Services Offered, Business Models	There are a wide variety of systems, each with its own set of services (such as transit price reductions, subscription parking, and accessibility via housing designers) and packages (such as deposits, premium services, reimburse). Some technologies are designed for short-term car use, while others permit for longer periods of time.
Vehicles	The automobiles themselves are the mainstay of any fleet-sharing scheme. Typically, these are cars, although SUVS may also include bikes and other forms of mobility (such the Segway Human Transporter, an electrical scooter). The quantity, variety, and power source of vehicles are common points of comparison.
Customer Service	Service quality is essential, and systems may provide any degree of support for customers, from basic to advanced (e.g., smartcard vehicle accessibility, online reservations and 24-hour roadside assistance)
Technological Sophistication	Vehicle-based technologies may be used to facilitate system operations (such fleet control) and the user interface, both of which are crucial for improving the user experience and making the system more manageable (e.g., billing and reservations).
Sources of Support	A decreasing number of car-sharing networks can sustain themselves via user fees; the majority still relies on grants and other forms of government funding, as well as, more recently, private entrepreneurs (e.g., angel investors, automakers, and venture capital).

It is common practice to ride in a shared station car. Some of the more forward-thinking companies in the car-sharing industry now offer "hybrid" versions that combine characteristics of both conventional car-sharing and classic station cars. For instance, there were 12,098 members in U.S. carsharing programs and 455 automobiles in operation as of July 2002, while 163 people were a part of station car programs, which included 121 vehicles [2]. According to Wang, Mirchandani, and Zheng [3], the incorporation of ITS technology is a crucial part of today's ridesharing systems. Technology like this has the potential to greatly improve the effectiveness, convenience, and controllability of ridesharing services. A variety of ITS user services may be put to use: Intelligent tracking and communication systems provide vehicle identification/location, electronic debiting, and emergency messaging; a) reservations and scheduling models, allowing various users to access system data, check out cars, and make reservations by phone, online, kiosk, and other channels, among others; b) travel information and on-board navigation to assist users of the system; c) smartcard technologies to assist with vehicular accessibility control; d) on-board smartcard technologies to potentially assist with vehicular accessibility controls; and e) Carlink II program and UCR IntelliShare testbed are only two examples of how sophisticated technologies like these have been created and deployed in the context of shared use vehicle research.

Among commercial carsharing businesses in North America, only 39% employ highly automated systems, while 17% provide somewhat automated services, and 44% rely entirely on human labor. There are 60% carsharing businesses that are completely manual, and 40% that are somewhat automated in Canada. Operator phone networks and in-vehicle trip records are examples of manual processes in the technological study conducted by Carsten, Andel, Yampolskiy, and McDonald [4]. Reservations made by automated touch-tone telephone or the Internet, or both, are examples of a partly automated system. It will become more difficult to manually manage bigger fleets of vehicles and diversified marketplaces for users (e.g., one-way rentals for rentals) as SUVS continue to proliferate.

Most corporate SUVS groups have not used advanced technologies so far because of the significant expense of setting up such systems. There will be a greater requirement for interoperability across shared-use system components and service providers as the market for these services expands. Additionally, the California Department of Transportation received a $3.6 million grant from the California Transportation Commission (CTC) in September 2002 to launch a two-year countrywide carsharing scheme [5]. CTC adopted this scheme with the stipulation that grantees make their services compatible with those of other carriers, allowing consumers to access a variety of statewide shared-use automobiles with a single smartcard. These regulations will have an effect on the three components of all SUVS models: consumers, system operations, and cars. From the standpoint of the consumer, it is advantageous for SUVS operators to offer a high level of interoperability and predictability across different SUVS and with transportation. A prime example of this would be the use of a single access strategy (like a smartcard or key fob) for several SUVS, as well as other mobility services like transportation and parking management. It is possible to standardize billing across many programs so that participants just have to keep track of one monthly charge rather than numerous. For consumers' sake, it's important that diverse systems adhere to the same operating standards.

Functional models of SUVS inevitably lead to varying operational standards (i.e., purpose, location, etc.). Consequently, implementing uniform standards of operation across all models is challenging. However, there is a pressing need to quantify the efficiency of SUVS with regards to modal interconnectivity, air quality, economic feasibility, energy efficiency, and insurance risks. The minimal information necessary to record vehicle utilization, net benefits, and claim histories might be outlined in operational guidelines. Having standardized procedures in place would make it possible to evaluate different systems' efficacy and create a uniform insurance risk category. The insurance market has not yet classified shared-use automobile services into a risk class (i.e., predicted loss probability).

Being unable to fit into a certain insurance category has a number of drawbacks. First, it is difficult for businesses to anticipate automobile prices since policies vary greatly across providers (i.e., There is no benchmark). Second, insurance companies are less eager to test out other markets, leaving organizations that facilitate the use of shared vehicles with fewer opportunities (and lesser consumer power as a result of reduced competition). Third, higher premiums reflect the uncertainty of risks and the costs of establishing novel classifications. Renewing memberships increased by an average of 50% in 2001-2002, according to most U.S. SUVS classifications. An insurer requires a trustworthy historical information collection to identify potential risks across different times and circumstances in order to establish a premium for a novel classification of the SUVS providers. Large samples collected over a minimum of three years are required to establish credibility. Thus, as this emerging market matures, there will likely be a greater need for operational standards with regards to insurance paperwork.

According to James [6], there are several established criteria for the safety, reliability, and compatibility of car parts. Some standards for shared-use on-board electronics are anticipated to develop so that manufacturers may create cars that can interact with and perform more consistently across various SUVS. The on-board control and monitoring electronics of shared-use cars, for instance, might all utilize the same interface (or connection). Manufacturers of technology for shared-use cars would do well to standardize on a few key features for this expanding sector (e.g., smartcard readers placed in vehicles). There is still a need for innovation in the transportation sector, and imposing regulations on SUVS at this time would be premature and too restrictive. Avoiding early stifling of new, creative operating approaches by standards is essential. Therefore, in the near future, it is important to create system interconnection, develop standard reporting criteria to show advantages and establish a shared-use auto insurance categorization, and promote certain common operational processes to eliminate potential obstacles to users' usage (for instance, billing, identical reservation, and vehicle accessibility processes).

This article outlines the growing operational techniques and common technical concerns in the field of Shared-Use Vehicle Systems (SUVS), with an eye toward fostering interoperability across systems of this kind. Everything from vehicle administration to system functionality is covered here. In this analysis, we assess the qualitative advantages of alternative system designs and illustrate the trade-offs that must be made while doing so.

The rest of the paper is structured as follows: Section II focuses on a survey of vehicle management reflecting on an illustration of a steady increase in automobile sales. Section III focuses on a review of shared-use technology fundamentals in system operations, with key discussions in On-Demand Vehicle Requests and Reservation Systems Concern, Vehicle Accessibility Concern, Communication Architectures and On-Board Vehicle Electronics Concern, On-Board Vehicle Electronics Concern, and Wireless Communication Architectures Concern. Lastly, Section IV provides a brief conclusion to the research.

II. VEHICLE MANAGEMENT

Motor vehicles have evolved to play an integral part in modern society. **Fig. 1** shows the steady increase in automobile sales throughout time. The great majority of people use cars for their everyday commutes. A common problem, however, is a lack of attention to the vehicle's maintenance schedule.

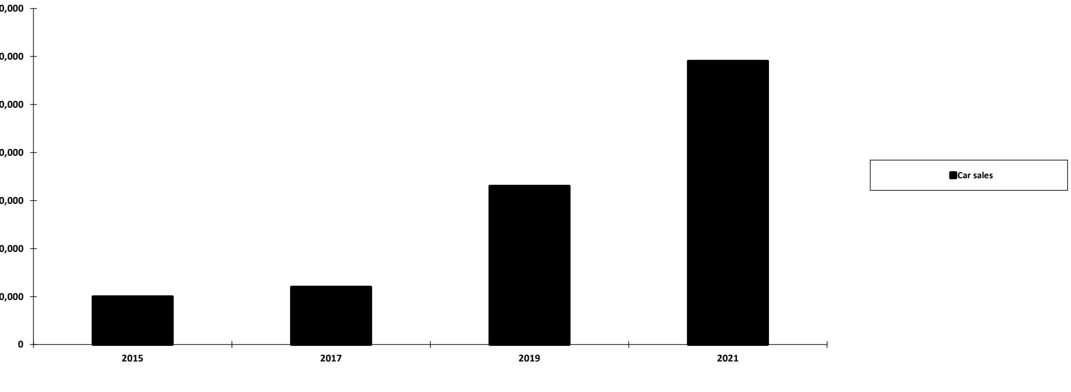

Fig. 1: Steady Increase in Automobile Sales

According to Pan, Pan, Jiao, Song, and Ming [7], a well-maintained vehicle uses its fuel more efficiently and operates more smoothly. A further problem is that customers expect repair shops and dealerships to treat their vehicles with the utmost care when they bring them in for service or maintenance; however several accidents involving motor vehicles are reported annually as a consequence of their carelessness. When you bring your automobile in for repairs, having faith in the mechanic is essential. Customers are often exploited in the name of service. Substituting inferior, obsolete components for the originals is a major problem. It may also be difficult for customers to verify that service providers are really doing the work for which they are paying. Businesses exploit the situation by charging excessive fees. The term "periodic vehicle maintenance" refers to the widespread practice of regularly scheduling maintenance and repairs for a vehicle.

The lifespan of a car is normally established according to either a fixed amount of time or a maximum number of miles driven. The vehicle should be maintained every six months or 10,000 kilometers, whichever comes first. The issue with so-called "periodic vehicle maintainability"" is that it may be difficult to tell which components really require fixing, which can lead to unnecessary repairs or replacements. Useful in this case is predictive vehicle maintenance. Many standard and aftermarket sensors in the vehicle collect this information to report on the health of the car's inner workings. This information is sent via the internet for the sake of analysis and decision-making, and the future failure probability is forecasted. This method provides clarity for the customer, who can then make informed decisions about when and what to address in their vehicle's maintenance. It is possible that certain systems may need maintenance or repairs ahead of their regularly planned interval. This issue is efficiently handled by the solution since the user is immediately notified through their mobile app.

It is important to address numerous problems inherent to shared-use cars before providing a range of operational techniques at different stages of technological implementation. Cars, as noted by Barth and Shaheen [8], are often the "vehicle" in a shared-use scheme. Nonetheless, this is not always the case, as schemes like this may also accommodate bicycles and scooters. Indeed, when people are initially exposed to the idea of carsharing, they generally think of shared-use bicycle networks. However, this article narrows in on cars as the major mode of transportation for a shared-use system. The cars in a fleet may all be the same (a homogenous fleet) or there may be a wide variety of makes and models (i.e., heterogeneous fleet). When dealing with a homogeneous fleet, the case selection procedure might be focused on vehicle features such accurately matching the amount of gasoline to scheduled journeys since all cars are expected to operate in the same way and on-board car technologies are systematically integrated. When it comes to Shared-Use Vehicle Systems (SUVS), however, having a selection of vehicles from which to choose is crucial for ensuring that each ride is optimized for its intended purpose. For carrying bulky products that would be too cumbersome to fit in a passenger car, a pickup truck may be the best option for the client. Each vehicle variety will have unique characteristics, and juggling many vehicle attributes may be challenging for management algorithms, making the fleet management challenge more challenging when dealing with a diverse fleet.

According to Elmashhara, Silva, Sá, Carvalho, and Rezazadeh [9], most car sharing programs fall under the category of "short-term rental," where cars are kept for a limited amount of time and driven for short distances. Since this is the case, many experts believe that EVs powered by batteries may work well with shared-use infrastructure. Problems with electric cars' restricted range include a shorter driving range between charges (as compared to conventional internal combustion vehicles) and a longer time spent plugging in for a recharge. Since travels in a shared-use vehicle situations are typically short, and cars may be charged while waiting at holding sites, these restrictions are mitigated to some extent. The CARB (California Air Resources Board) suggested an extra ZEV (Zero Emission Vehicle) application credit for reduced emission automobiles placed into SUVS back in 2001 because to the various synergies between clean fuel cars, stations car, and car sharing programs.

Additional credits would be made available for clean fuel vehicles that are either connected to public transportation or used in high-tech carsharing systems [10]. For sales in California to begin in 2003, the ZEV program mandates that high-volume manufacturers create cars powered by clean fuels. SUVS, in particular when low-polluting vehicles (such as rechargeable electric, liquefied natural gas and electric hybrid) are added to transportation networks, are a major motivation for CARB's linking of technological and demand management approaches (e.g., carsharing models connected to transit). However, as we will see, there are some extra challenges in managing shared-use cars when dealing with automobiles that have a limited range and a lengthy recharging time. The promotion of SUVS may be greatly influenced by the cars themselves. Unique, modern, and enjoyable automobiles are a great selling point for a SUVS, since they are more likely to attract new members. The administration and operations of SUVS will be the topic of the following section.

III. SHARED-USE TECHNOLOGY FUNDAMENTALS IN SYSTEM OPERATIONS

Previous Research

There are generally three primary concepts for Shared-Use Vehicle Systems (SUVS). In this study, we define these methods via a historical lens. Among them are shared-use vehicles with several nodes, station wagons, and carsharing in residential areas. As a result of technological advancements (such as computerized and wireless communications networks) that make system administration and vehicle access easier, the first two designs have recently begun to diverge dramatically from their initial ideals. The original carsharing and stations car ideas have converged to share features (e.g., commuter carsharing). The multi-node strategy is critically evaluated below:

The Neighborhood Carsharing Model

According to Gonzalez and Quadros [11], the present trend of car sharing among neighbors began in earnest in Europe fifteen years ago. People who desired the convenience of a car but could not afford to own one, pay for parking, and maintain it were the original impetus for carsharing. In response, a number of carsharing groups were formed, each with a small fleet of shared automobiles. While some of the first car-sharing initiatives fizzled out, others succeeded in expanding beyond the grass-roots, neighborhood-based programs that spawned them. There are now literally hundreds of thriving car-sharing businesses operating in a wide variety of locations around the world. Readers interested in a current list of these carsharing groups are directed to a number of active websites that are dedicated to carsharing operations, such as those listed by Yao, Gendreau, Li, Ran, and Wang [12]. The standard carsharing service of today deploys a fleet of automobiles to central parking garages spread out over a congested urban area.

Members often make prior reservations for shared-use automobiles [13]. Users must rent and return a car to the same lot throughout one continuous rental term; this kind of rental is also known as a "two-way" rental since users must rent and return a car to the same lot during the rental duration. When participants make use of a car, they are responsible for the cost of doing so (usually based on time and miles). The carsharing company as a whole is responsible for the upkeep of the fleet of cars (such as light trucks) over the network of facilities, making vehicles accessible to users in residential and commercial areas. In most cases, little membership fee will have to be paid per month or make an initial deposit. In most parts of the world, those who want to utilize a shared vehicle go via a carsharing service. The automobiles are mostly seen in residential regions, with occasional sightings in commercial districts and rural areas. Essentially, the idea behind carpooling is straightforward: People pool their resources to cover the expenses of a vehicle's short-term use. In order to make it easy for carsharing members to get behind the wheel, parking lots are strategically placed throughout cities. In many cases, when people start carpooling, they end up using public transportation more often (or taking up other forms of transportation, like bicycling) because they realize the true expense of driving alone.

Station Cars

Station cars are another kind of public transportation vehicle sharing system. However, it was in the United States that the station car idea was put to the most rigorous testing. The original and still most common kind of station car is a fleet of cars stationed at urban train terminals and used mostly by commuters at the beginning and conclusion of their journeys. Most of these initiatives have been taken up by rail transportation companies in an effort to improve parking constraints and boost transit use. Historically, the primary purpose of station cars was to improve transportation connections, rather than to facilitate group travel. Station car programs, in contrast to carsharing, often have fewer users per vehicle. However, beginning in the mid-1990s, a number of studies started to investigate shared-use methods as part of the station car idea (particularly in Asia through the integration of electronic and wireless technologies).

Station wagons stationed at significant train stops along a commuter corridor may provide a flexible feeder service for commuters at both ends of their journey. A user may, for instance, drive a station wagon from their house to a local transport terminal and leave it there or nearby while they are at work. The client then travels to their location by train or bus. A second station car might be leased after an individual reaches their morning commute's final destination station, and then used to go from the station to the workplace and back again, as well as for other errands and appointments during the day. User drives the station vehicle from their place of employment to the station in the evening. In order to go home at the end of the workday, this person transfers to yet another station car. "Reverse" commuters in this case often use the same designated station car from one station to another, either to or from their place of employment or their residence. Other users might make use of the cars throughout the day, when they would otherwise be idle at a station, to do journeys that aren't part of their commute.

Multi-Nodal Shared-Use Vehicles

A more generic type of SUVS involves moving automobiles from one set of stations, or nodes, to another. Resorts, amusement parks, national parks, and college and university campuses are all possible settings for such infrastructure. Users may arrive by train or aircraft, and then hire a shared-use car to get them to their hotel. Someone staying at a hotel may leave later to visit a nearby mall or landmark. As a result, rather than the usual roundtrips conducted in a station car or neighbourhood carsharing program, the excursions are more inclined to be one-way each time. Similar to carsharing, users split the bill for gas and wear and tear on the vehicle. With so many one-way journeys in a multi-nodal situation, the shared-use vehicle population at each station may rapidly become unbalanced.

The number of available automobiles at each station ebbs and flows throughout the day, with some garages stocked to capacity while others struggle to keep up. Therefore, it is occasionally required to periodically reposition cars daily so that the system functions effectively and (most) users' travel needs are fulfilled. Although not usually connected, multi-nodal systems might potentially be directly linked to transportation. One benefit of a multi-nodal system is the option for one-way excursions rather than round-trips. One-way rentals provide more convenience for travelers, but they also present new challenges for fleet managers due to issues like vehicle repositioning. Recent technological advancements have made multi-node systems not only more manageable, but also more cost-efficient.

A user in a generic SUVS links the system organization by providing a one-time registration charge and then a recurrent subscription price, or both. In order to utilize a shared-use car, there are many procedures a user must do after becoming a member:

1) A reservation system may be used to reserve a car for a given amount of time and for a specific place if a journey is planned in advance. While the system is in operation, the SUVS, on the other hand, may allow customers to check out a vehicle "on demand" if they need to make a last-minute journey. Some systems may provide access to autos both ahead of time and on demand. (An on-demand request is similar to making a reservation for a time period that is one to fifteen minutes away.) Check-out processes on demand and reservation systems are discussed in the section that follows.
2) During the time for gaining accessibility to the vehicle for the destined trip, there are different ways to do so, all of which are covered in the section below.
3) Information may be exchanging between the car and system while the user is inside and operating the vehicle for better fleet management and driver assistance. A lot of this is dependent on the communication architecture that has been built and any on-board car electronics.
4) The system administration may record the data, carry out the proper accounting and invoicing, and carry out any other "back-office" tasks to effectively oversee the whole scheme after a trip has been executed successfully. Trip data typically includes details of duration and time.

More information about this is provided below. Each of the components of intelligent SUVS that were mentioned in the preceding phases is examined in this part.

On-Demand Vehicle Requests and Reservation Systems Concern

The most basic systems (also known as "manual" operations) allow a user to phone a reservation center (also known as a system management station) and request a car for a journey. A time window is then recorded if one is available after an operator has checked prior bookings for the desired vehicle or vehicles. Automated reservation systems have significantly advanced and proliferated across society as a whole during the last several years. For instance, automated reservation systems are currently used by the accommodation, conventional vehicle rental, and airline businesses. These systems may be used both over the phone and online, with data entered via a touch-tone pad. It makes perfect sense to have automatic reservation schemes, which could be accessed through the web or/and phone for shared-use vehicle schemes.

SUVS may readily be implemented using generic automated reservation systems; minimal specialized knowledge is needed. The majority of online automatic reservation systems features a straightforward, user-friendly interface and displays a calendar with available car dates and hours. Users who make reservations benefit from the security and comfort of knowing that a car will be there for them when they need it. Reservations are helpful for system administration as well since they let the system optimize vehicle utilization all day long. Reservations might be crucial in ensuring a suitable vehicle allocation at all stations during the day for multi-nodal SUVS when one-way journeys are often made. It is feasible to predict when a shortfall of cars may arise at any one station by understanding the travel demands in advance via bookings, and remedial action may be taken.

A user submits a reservation request (online or over the phone), the user arrives at the vehicle and secures entry, and the user completes the journey. Information about the journey is recorded after it is over (either through communication or manually between the scheme and vehicle). Even though a reservation can ensure the safety of users' excursions and improve system efficiency, not all of our trips include vehicles. On-demand car service is often required in situations when a vehicle is needed immediately. Users benefit greatly from on-demand access to shared-use automobiles, but system management must work harder to meet increased demand. There are now on-demand SUVS (systems that do not allow for reservations) that utilizes trip history data to predict future vehicle demands (e.g., in its three years of existence, the UCR IntelliShare software has solely provided on-demand services). The reservations system is eliminated using a "check-out" method in which users tend to interact with kiosk terminals positioned in close proximity to the shared vehicle(s).

In most cases, checking out a car entails navigating a few of input data panels. After a successful check-out, the user may access the reserved vehicle and begin the journey. In certain SUVS, the user need just approach an available car to check out and get access to the vehicle, eliminating the need for a kiosk interface. All that's needed is for the automobiles to prove they're ready for action (e.g., a minor green light in the window of a car pool might let other drivers know that the car is free for use). The use of a station-based kiosk terminal may appear superfluous for on-demand car check-out, but there are a few scenarios in which it is useful.

1) If a station houses a fleet of uniform automobiles, the kiosk computer, operating under the direction of system management methodology, could play a vital role in choosing among the available automobiles. If all available cars are equivalent and can meet the requirements of the trip, then additional criteria may be used to determine the vehicle to be utilized, such as the vehicle's fuel level or a rotation of vehicles to ensure that each vehicle is used about equally over time.
2) Even with reservations, the usage of a kiosk-based check-out becomes particularly advantageous if the cars being rented have a poor range and a long refueling time (such as electric vehicles). Vehicle selection should be made just before departure because the fuel levels (charge state within EV) might vary greatly according to the number of prior journeys and the length of the charging sessions. The algorithm for selecting a vehicle with sufficient gasoline or energy for a journey uses user estimations to make its decision. As it is impossible to know how full a certain vehicle will be in advance, it is best to choose a vehicle at the station kiosk on the day of the journey, even if a reservation system is in place. A station-based kiosk check-out procedure is unnecessary for short-range, slow-refueling electric cars if a time-buffer is included into each reservation.

This is because drivers will have enough time to recharge their vehicles before they are due to be used. This mode of operation, although practical, does not make the most efficient use of available vehicles.

A wireless PDA or internet-enabled mobile phone may eliminate the need to visit a kiosk before gaining access to a car. In this scenario, rather of visiting a physical kiosk, a consumer would instead go online to a site that handles the checkout procedure. Existing shared-use car systems sometimes let users to make reservations just a few minutes before the actual journey, allowing for on-demand usage. Indeed, 50% to75% of bookings on many reservation-only shared use car systems are for travels on the same day. Reservations and on-demand usage may be combined in a SUVS to increase efficiency. The goal is to strike a good balance between reserved and on-demand usage of the vehicles so as to reduce overall unused time. By adjusting prices, we may encourage more efficient use of vehicles and increase mobility. In order to minimize the amount of people using services on short notice, this is the standard procedure for rail and aircraft seats. In the event that a flight is oversold, it is not uncommon for the airline to give customers monetary incentives to reschedule their travel. In order to solve this supply-demand puzzle and optimize financial return and vehicle utilization, several algorithms may be designed. There has to be a balance between pre-booked visits and impromptu use, and both the short- and long-term effects of this should be taken into account. While restrictions in the short term may be flexible to accommodate fluctuations in daily travel demand, it is crucial to keep customers happy in the long run if considerable usage is to be sustained.

Vehicle Accessibility Concern

Numerous methods exist for restricting access to vehicles, including the use of check-out on-demand or/and reservations. Various types of SUVS have led to the development of a number of techniques shown in **Table 2**.

Table 2. Various types of SUVS Techniques

Lockbox	Users of a shared-use vehicle system need only keep track of one key to unlock a lockbox. The keys to the various cars are kept in a lockbox. Additionally, several systems now provide entry to the safes using widely-available smartcards.
Common Keys	All of the automobiles in this case are re-keyed so that one set of keys will open all of them. This way, everyone may use the same key to get into any of the vehiciles (such as CarLink II).
Smartcard Open Access to Cars	Smartcards may be used as a key replacement when paired with on-board electronics (such as card readers linked to door lock systems). Here, any smartcard inside the system may be used to get access to any vehicle. Once inside, the driver would use a key that was either permanently attached to the car or tied to their person (or, as seen in Honda's ICVS initiative in Singapore, a key that sprang up from the ignition). Since different users may gain access to a vehicle at any particular time, this approach, like the standard key and lockbox systems, relies on a user's good faith to enforce reservations.
Smartcard Exclusive Access for Specific Users	Users are given smartcards in a manner similar to that described above. A smartcard's unique code is used in conjunction with a Personal Identification Number (PIN) to provide entry to a desired vehicle. In order to implement this kind of access control in a vehicle, the smartcard code should be sent to the car in advance of the time the user will need to enter the vehicle. Once inside, the user may turn the ignition using the same key that is either permanently attached or connected to the automobile.
Exclusive Smartcard Access for One User with PIN Confirmation	A smartcard code is used to provide access to a particular user for each journey, much as the first technique described. Once inside the vehicle, however, the user must take an extra step by entering a PIN into input devices (or message display terminals, typically found on the dashboard) to initiate the engine. This may assist prevent criminals from using stolen credit cards in the same way that ATMs do.

Key "fobs" (i.e. small devices hanging on the key chains) could be employed in place of a smartcard for any of the available alternatives. These AWID-compliant key fobs are used by the biggest carsharing service providers in the United States. Furthermore, by establishing short-range interactions (using infrared) with the car, Personal Digital Assistants (PDAs) as well as other wireless devices, such as smartphones, might be utilized for keyless entry. Each of these methods of providing access to vehicles involves some compromise in terms of efficiency, safety, or expense. **Fig. 2** provides a qualitative comparison of the different access methods in terms of both cost and level of security. Since users should go through an additional step to get the keys, the lockbox technique increases the car's safety only a little bit. The common key technique is the least secure since a single stolen key could be utilized for the whole fleet. The smartcard open-access approach enhances security since a user who discovers a misplaced card may not be able to use it.

The sole use of a smart card offers a higher level of security, but only if the vehicle can receive and decipher the codes on the card. The most secure entry method—smartcard-exclusive with PIN—has the additional expense of having a PIN input device within the vehicle and offers the highest level of protection. The cost-benefit analysis between user-friendliness and accessibility is shown in **Fig. 3**. Since users will need to take the extra step of locating and opening a lockbox, this approach is less convenient than others. Although sharing a key across many cars is quite practical, it does come at a cost. Both the smartcard exclusive-access and open-access options are premeditated with the user's convenience in mind. The smartcard exclusive access with PIN system is inconvenient because it adds a step before starting the automobile that must be completed with the use of a personal identification number.

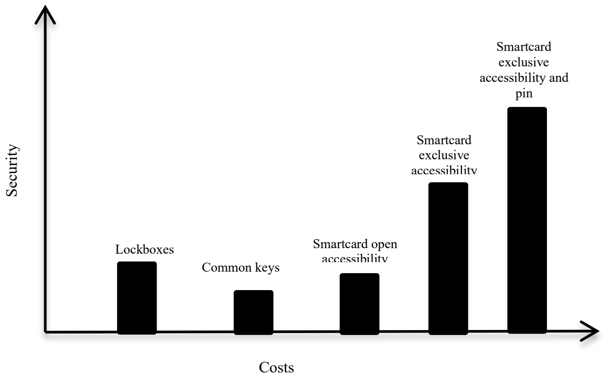

Fig 2. Tradeoff Between Costs and Expenses for Different Entry Techniques

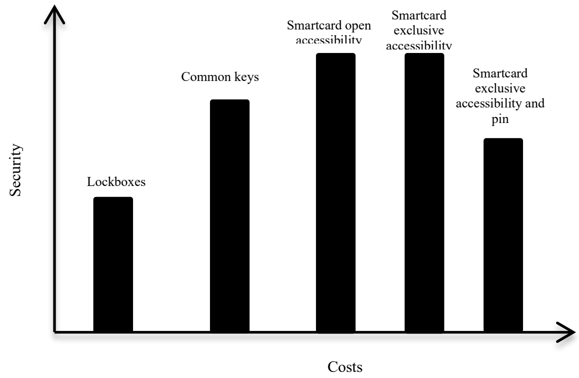

Fig 3. Security and cost trade-offs for Various Vehicle Entry Techniques

Communication Architectures and On-Board Vehicle Electronics Concern

There is a lot to be gained by installing electronics in cars as part of ITS for shared-use automobiles. Electronics installed in a vehicle can perform four main tasks: 1) controlling entry to the vehicle; 2) collecting information about the trip and the vehicle's efficiency (such as the state of charge); 3) enabling Automated Vehicle Location (AVL); 4) enhancing navigation and systems/users communication. To perform all of these functions, a single black "box" is often incorporated and mounted in the vehicle.

On-Board Vehicle Electronics Concern

Vehicle Access Control

Vehicle Access Control (VAC) [14], as previously mentioned, boosts both user-friendliness and system security (Possibly resulting in reduced insurance costs). Card readers (such as AWID scheme employed by leading carsharing firms in the U.S.) and interfaces to the car's door lock circuitry are the bare minimum hardware parts needed for smartcard-based vehicle access management. If a person waves a valid smartcard in front of a reader, the doors will open. Discrete hardware components, rather than a central processing unit, may be used to accomplish such a basic function. But if an exclusive smartcard access mechanism is implemented, the hardware requirements will rise. To guarantee that only approved users have access to cars at the appropriate times, the system must communicate user codes to each vehicle. Because of the increased complexity, a microprocessor or microcontroller is usually needed to keep track of code variables and run preconfigured state machines to ensure the correct sequencing. While adding dashboard-mounted keypad systems for PIN input does increase the total physical complexity of the on-board electronics, it does not greatly increase the complexity of the microcontroller systems.

Vehicle and Trip Performance Data Acquisition

Electronics installed in vehicles also have the useful function of automatically collecting trip data that may be utilized for a variety of reasons, not the least of which is invoicing and analysis of vehicle performance (e.g., status of charge). Individuals using a manual system generally maintain a journal or logbook detailing their travels, documenting details such as check-out and check-in times and distances traveled. Operations may experience delays due to the time required for collecting and inputting such information. Additionally, the system depends on the integrity of its users. By connecting with the odometer signal and using on-board real-time clocks, on-board electronics could be configured to record similar characteristics. This information, like that of the City CarShare system, may be easily kept and accessed at a later timeframe by system administration employees (e.g., once after some weeks). Or, you may use wireless communications to report your journey details back to the system. It is simple to expand this set of data to integrate helpful information bits if electronics are transferred on-board for such as minimum set of trip features (i.e., trip distance, and trip length). The fuel level, the voltage of the auxiliary battery, gear selected, door close/open signals, etc., may all be additional parameters. Below we discuss how position data is an important data parameter, especially for multi-node SUVS. When launching a SUVS, it is important to gather as much information as possible, especially in the beginning, so that the system's overall advantages can be shown.

Automated Vehicle Location Capability

Location data may be important in some forms of SUVS. For instance, in multi-nodal systems with numerous one-way journeys, it is helpful to know where cars are at all times and their historical trajectories in order to maintain a steady number of vehicles at each station. Furthermore, keeping track of where people are going on errands might help in deciding where to set up additional stations. Vehicle-mounted GPS devices, as well as terrestrial radio triangulation, are only two methods for pinpointing a mover's exact location. Location and trajectories data may be recorded and retrieved at a later time rather than communicated in real-time (e.g., ignition on-and-off). In order to better manage the fleet, AVL technologies are often installed on buses. But there are privacy concerns with AVL systems put on (semi-)private cars, such as those in a shared-use system. It is crucial that personal user information be kept separate from vehicle location information before any analysis is performed.

System Messaging and On-Board Navigation

When more features are added to the vehicle's electronics, it becomes easier for drivers to go where they need to go and find fuel. In the event of an emergency (for example, "flat tire," "out of gasoline") or to increase the duration of a reservation, it might be helpful for users to be able to send messages to the system. Users and general system performance may benefit from this new feature.

Fig 4 demonstrates how installing electronics into a car may greatly improve system management and provide a more pleasurable driving experience for customers. The aforementioned features may either be implemented independently or combined into a unified whole. One of these features may be disabled or removed entirely to leave only the VAC capability. The same holds true for trip data gathering, which may be used alone or in conjunction with the other features. However, the two services—trip data acquisition and vehicle access control—are sometimes sold as a bundle, with substantial savings for the system administrator. Access management and data collection systems in vehicles are often not deployed without AVL and navigation features. These boost the overall performance of the system and provide more ease for the user, but they come at a higher price.

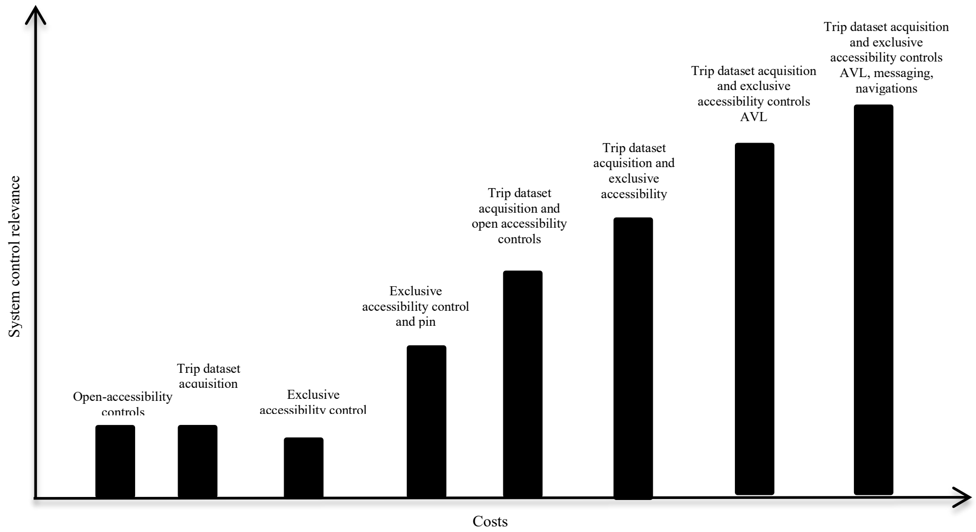

Fig 4. System Control Relevance Against Costs for Installing Electronics into a Car

Wireless Communication Architectures Concern

Recently, the field of wireless communications has been buzzing with intense activity. Safety, maintenance, remote diagnostics, enhanced vehicle control, and traffic management are just some of the numerous uses for the plethora of communication links used in various ITS applications. (Many refer to the work done in this field as "telematics.") Sharing vehicle systems may benefit greatly from wireless communications, especially for sharing data between users, the network, and the cars themselves. It is feasible to add electronic gear on board to automate trip data collecting and apply fundamental approaches to controlling access to the vehicle, as was discussed in the preceding section (On-Board Vehicle Electronics). Wireless connections between the network and automobiles, however, provide significant benefits. By way of example, the system may transmit the user's code to the desired car for use in exclusive-user VAC. The car's computer will save that code and look for a matching one from the card reader. There will be signals transmitted to open the doors after the codes are entered.

Having the ability to "lock out" unauthorized users is becoming more crucial as systems grow and enter new markets (e.g., employer-based fleets). In addition, rather of having to manually download data loggers every few weeks, it is far more easy and cost-effective to have the cars broadcast trip data to the system using wireless communication receivers. For this reason, wireless communications are widely used in SUVS. Besides AVL capability, the system and users may communicate briefly by text message and in an emergency, a mayday signal can be sent via wireless communications to alert others to the location of the shared-use car. In the realm of SUVS, numerous wireless communication topologies are available for implementation. The model of the system, the system's intended usage, and the available budget all have an impact on how the wireless communication architecture is conceived. A few of the most frequent communication structures are described here.

Local Communication Architecture

Users may reserve and, in certain cases, check out automobiles for shared usage via the service's website. A server dedicated to system administration takes care of these inquiries. Dedicated Short-Range Communication (DSRC) methods allow for system access information to be downloaded to shared-use cars while they are parked or waiting at a station. Likewise, whenever a shared vehicle has completed a journey, the data from that trip may be uploaded to the server that manages the fleet. Applications for DSRC in the ITS field include vehicle identification, electronic toll collections and others that need communication between moving vehicles and fixed infrastructure. Short range (approximately100 meters) with high data speed and dependability characterizes this form of communication. When vehicles' status upgrades are not required when they are away from their parking site or station, this architecture is useful. Once the cars and the system are at a very close proximity to one another, communications may take place. In addition to not needing any special permissions or membership fees, short-range communication also does not cost anything to use. After a site has a dedicated short range communications process installed and is linked to the systems' server (via the web or specialized lines), there are no more expenses.

Wide-Area Communication Architecture

The communication framework may also be designed with a focus on wide-area wireless networking, which is considerably distinctive to the local communication-based infrastructure that is more often used. There is no set area where cars must be in order to connect with the system. Communication between the infrastructure and automobiles may instead take place through cellular networks. The use of wireless IP networks, such as Cellular Digital Packet Data (CDPD) [15] and General Packet Radio Service (GPRS) [16], is now the norm throughout most of North America. Most of the time, they are the ones sending packet data traffic via unused cell phone channels, making this service available to mobile consumers. Because of this, ITS applications that need long-distance data transfers have mostly focused on CDPD and GPRS. Multiple mobile end systems share a wireless connection with a data transfer rate of 19.2 kilobits per second or more, which allows them to talk to the CDPD or GPRS network. It is possible to build a connectionless downlink by broadcasting packets from networks to end-user systems. CDPD utilizes standard slot, non-persistent Digital Sense Multiple Access (DSMA) protocol for the uplink direction. To further strengthen the data channel, we use several intelligent wireless methods including RS coding, frequency hopping, variable channel relocation and roaming. A monthly membership charge is required to build such a wide-area telecommunications network. In addition, packet data loss and data packet lag are inevitable in a wide-area communication networks and might disrupt the functioning of a shared-use car system.

IV. CONCLUSION

This paper provides a critical survey of the different fundamentals of intelligent Shared-Use Vehicle System (SUVS), such as reservation systems, vehicle access techniques, on-demand vehicle requests, on-board vehicle electronics, system management functions and communication structures. In the discussion of the fundamental, various concerns are discussed critically: on-demand vehicle requests and reservation systems, vehicle accessibility, communication architectures and on-board vehicle electronics, on-board vehicle electronics, and wireless communication architectures. In comparison to standard practice, the advantages of intelligent technology techniques were assessed qualitatively. U.S. suppliers of shared-use vehicles are now making the transition from manual, low-tech operations to automated, centralized, remotely controlled systems. Vehicle security, trip recording accuracy, user comfort, vehicle management, system efficiency and accounting systems are all areas that have benefited from the rise of increasingly sophisticated electronics. Historically, systems for sharing vehicles have been started by groups of people interested in pooling their resources. Since this movement began at a grass-roots level, it did not have to worry about things like maximum safety or convenience. In order to remain competitive with the ease of owning a car, SUVS will need to increase their dependability, responsiveness, and efficiency. This article discusses Intelligent Transportation System (ITS) technologies that are now available and suitable to several forms of shared-use vehicles.

Data Availability

No data were used to support this study.

Conflicts of Interests

The author(s) declare(s) that they have no conflicts of interest.

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Ethics Approval and Consent to Participate

The research has consent for Ethical Approval and Consent to participate.

Competing Interests

There are no competing interests.

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