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STARS

Shared mobility opporTunities And challenges foR European citieS

Research and Innovation action
H2020-MG-2016-2017

Review of the Impacts on the Automotive Industry

Deliverable D3.3

Version n° 1

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Acronyms

CSLP	Central Sensing Localization and Planning
EV	Electric Vehicle
ICE	Internal Combustion Engine
ICT	Information Communication Technology
LMP	Lithium Metal Polymer
MIT	Massachusetts Institute of Technology
MPT	Micro Public Transport
NHTSA	National Highway Traffic Safety Administration
PHEV	Plug-in Hybrid Electric Vehicle
REMTM	Road Experience Management
SOC	System on a Chip

EXECUTIVE SUMMARY

- Car sharing has grown rapidly, despite a period of significant turbulence in the global automotive industry.
- Many new forms of mobility offering have emerged, creating a confusing and complex market.
- To the end of September 2018, car sharing has not had a strong influence on the automotive value chain, from materials and components through to End of Life Vehicle recycling.
- Design for car sharing is an emerging field but until volumes are sufficiently large there is not enough incentive to produce use-specific designs.
- Earlier attempts at vehicles designed for car sharing schemes (Hiriko; Autolib) have ended in failure.
- The future for car sharing in large part depends upon the fit of this concept with emergent ideas in the automotive industry concerning connectivity, electrification, and autonomy.
- There are synergies with concerning connectivity, electrification, and autonomy that will complement the growth of car sharing in the future.
- Connectivity offers a technological platform that helps consumers use car sharing schemes, and helps operators manage the schemes.
- However, connectivity also allows new entrant intermediaries into the automotive value chain.
- Electrification offers more benign automobility, that resonates with car sharing schemes that seek to reduce the negative externalities of car ownership and use on urban areas.
- However, electrification is still constrained by range and charging issues, as well as cost, which has so far reduced further uptake of electric cars in sharing schemes.
- Autonomous technologies could offer greater ease of use for consumers accessing car sharing schemes, and reduced costs and maintenance for operators.
- However, such technologies are not fully developed and the long-term impacts on the overall market are uncertain.
- New entrants are also likely to be a source of further innovation in respect of business models for car sharing.
- Equally, new brands from existing vehicle manufacturers have the opportunity to define new customer propositions without the ‘baggage’ of existing brand history and retail structures.

Overview

This task will collate evidence on the impact of car sharing services and associated business model innovation on the automotive industry value chain as a whole. Input into this stage will come from specialist websites (e.g. insideevs.com; fleetnews.com), industry data sources (e.g. automotivenews.com), industry representative bodies (e.g. ACEA; CLEPA, SMMT) corporate annual reports, consultant and other secondary source reports, and academic studies. Analysis will focus on those impacts that require an extension of traditional automotive industry competence via internal capacity building, or relationships with other companies via joint-ventures, alliances or acquisition.

The research will create a typology of business model innovations based upon the database of identified innovations, and using key criteria such as contribution to the value creation chain and degree of control by vehicle manufacturer. Some of these innovations are outside the control of the traditional automotive industry, and may result in significant disruption to important value streams for manufacturers, franchised dealerships and others currently involved. New intermediaries offering innovative bundled services that include but go beyond car sharing may dispute the primacy of vehicle manufacturers in the value chain. Moreover, the impact of car sharing schemes on the volume and model mix of manufacturers could be significant as such schemes grow in scale. This task will include consideration of e.g. vehicle financial life cycle, service and repair operations, and used car remarketing. CU, GM and LGI will cooperatively work in this task to finalise the review.

1 Introduction

In WP3.1 the business models of the main car sharing schemes were identified in which it was clear that much experimentation was underway. In WP3.2 the impact of car sharing on the market was analysed. In Deliverable 3.2, it was shown that car sharing is on a very small scale compared with other routes to the market for new cars. Furthermore, while car sharing as a concept goes back a long way, recent years have seen the emergence of alternative mobility forms including ride hailing, ride sharing, and electric bicycle sharing. Significantly, large public and private sector car sharing schemes were shown to be struggling for viability. Indeed, as Deliverable 3.2 was under preparation it was announced that there would be no further support for the Paris Autolib scheme in the face of mounting financial losses.

Nonetheless car sharing was also shown to have a place within a portfolio of transport planning options. The quest for liveable cities, including concerns over air quality, provide the basis for support for car sharing. New technology applications in software, enabled over mobile telephone networks, have greatly increased ease of operation. In short, there is clearly room for growth in car sharing.

Deliverable 3.2 also showed that car sharing fleets have a higher proportion of electric cars compared to the stock of cars in general circulation. It follows that car sharing fleets purchase a higher proportion of electric cars. In some locations, fleets are composed purely of EVs. There is an implied synergy therefore between EVs and car sharing. In turn, this raises the question of the 'fit' between car sharing and other emergent features of the automotive industry. This report, Deliverable 3.3, therefore focuses on how car sharing relates to wider developments in the automotive industry. The Deliverable will explain how far and in what ways these wider developments will be supportive of or inimical to car sharing.

In many respects the global automotive industry is in a period of unprecedented upheaval. It is the combination of developments that creates this turbulence, rather one aspect alone. The future of the industry is arguably more uncertain than at any point in its history. Car sharing is enmeshed within these developments and contributing to them. The contents of this report therefore reflect the methodology of 'longitudinal immersion' whereby the authors have been engaged with all aspects of the automotive industry for a protracted period of time to create a domain expertise (Wells and Nieuwenhuis, 2017). Included in the sources of turbulence are technological, regulatory, political, market and competitive issues. The pace at which change is happening is also highly uncertain, while impacts from the collective and cumulative changes will be differential according the vehicle manufacturer under consideration. As an illustrative but not exhaustive list we can include:

- The replacement of ICE cars with EVs and PHEVs at a faster rate than originally expected;

- The growth of anti-diesel sentiment by politicians, regulators, citizens and consumers;
- The emergence of powerful local anti-car lobbies;
- A strengthening of zero emissions or car exclusion zones;
- The need for immediate responses with respect to carbon emissions, illustrated by the Paris Agreement;
- The impact of digitization and connectivity resulting in a desire to capture and use 'big data' analytics in the realm of mobility;
- The deployment of varying degrees of autonomous capability in cars and other vehicles;
- The stagnation of many traditional markets, at least in volume terms;
- The shift in the 'centre of gravity' of the industry towards Asia, particularly China;
- The continued fragmentation of the market with increasing numbers of models and variants;
- The disruption to global trade instigated by the US under President Trump;
- The emergence of multiple new entrant cars and concepts created by traditional suppliers, sectors traditionally outside the automotive industry, and in new locations such as China;
- The creation of new relationships by vehicle manufacturers with non-traditional industry participants;
- The experimentation with innovative business models that create and capture value in ways that are new to the industry.

The impact of car sharing will depend upon both the scale upon which car sharing is adopted, and the interaction of car sharing with wider changes underway in the global automotive industry. While the impacts currently and in the short-term future may be understood as modest, **car sharing could be part of a wider systemic change in the automotive industry** that will redefine who participates in the industry, and on what terms (Pechmann et al., 2015). This shift is seen by many as comprising the **abandonment of the linear, product-centric model of the industry, to one which is increasingly circular and service-centric**. It is a transition from an automotive industry, to an automobility industry, in which traditional sector boundaries are increasingly blurred.

In this Deliverable section 2 outlines the impact of car sharing on the traditional automotive value chain. Apart from some dedicated schemes such as Autolib, no 'unusual' supply chain practices have thus far been entered into by the value chain to support car sharing. Section 3 then locates car sharing within the wider trends outlined above, using the Daimler 'CASE' framework to characterise the emergent automobility industry.

2 Car sharing and the automotive value chain

The automotive value chain is traditionally held to comprise a tiered or layered structure, following a model developed by Toyota in Japan. That is, there are three or four 'layers' of suppliers, with only the tier one suppliers having direct contact with the vehicle manufacturer. Finished new vehicles are then distributed via National Sales Companies to dealerships, which may be owned by the vehicle manufacturer, and then sold on to customers. As was discussed in D3.2, there are multiple routes to the market accompanied by variable rates of discount. Once in the market, other entities can participate in the value chain, notably those involved in finance, insurance, and vehicle maintenance and repair. The **main elements of the value chain** are therefore as follows (also illustrated in Figure 1:

- **Vehicle manufacturers**. Typically holding multiple brands, and achieving economies of scale with 'platforms' that are used with greater or lesser differentiation to produce a range of models per brand. The vehicle manufacturer is mostly involved in vehicle design, sourcing of components and materials, assembly, and then distribution and marketing. In-house finance operations are also important. In terms of manufacturing, the contemporary model is to focus on engine manufacturing, and the vehicle body. The vehicle body is constructed by stamping, welding (and other joining) and painting. Most other components and virtually all materials are outsourced. There are exceptions; for example, many vehicle manufacturers have captive suppliers of magnesium as it is considered a strategic material in scarce supply. BMW also set up its carbon fibre supply chain as a semi-captive operation, to ensure security of supply and quality of operations for the i3 and i8 models.
- **Tier one suppliers**. These suppliers provide the bulk of the added value of the ex-works (factory door) value of the car. Each manufacturer retains a relatively small number of tier one suppliers, with two or three per major product area. Substantial consolidation in recent years has result in quasi-monopoly positions emerging in this supply base in some instances. Tier one suppliers are expected to be the ones that **undertake R&D for new models, deliver completed modules or sub-assemblies to the vehicle assembly plants**, and manage the lower tier supply levels.
- **Tier two suppliers**. These suppliers typically **produce components for sub-assemblies** that are then assembled by the tier one suppliers. They will typically therefore supply pressings, welded sub-assemblies, extrusions, mouldings, castings, etc. The tier one suppliers will use a large number of these suppliers.

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- **Tier three suppliers** are those **making commodity items in large volumes** but **with low per unit values**, such as nuts and other fixings, electrical cable, etc. They are not necessarily specialised on the automotive industry.
- **Tier four suppliers** are usually defined as **materials suppliers**. That is, they supply steel, aluminium, plastic, etc. to the supply chain. Note however that the main material suppliers will also supply direct to the vehicle manufacturers (i.e. they will act as tier one suppliers) in for example steel for the vehicle body, or aluminium for the engine block. Materials suppliers often work via independent or captive semi-finished fabricators. These entities include steel stockholders or operations that perform laser welding of steel blanks for delivery to the press shop.

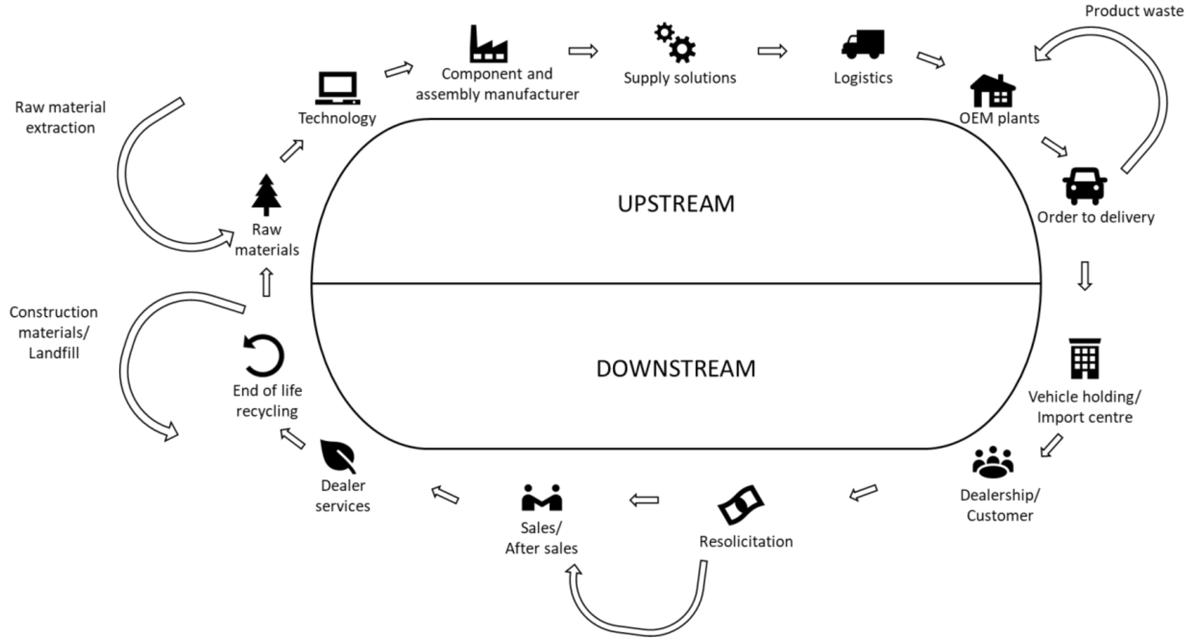

Figure 1: Automotive industry value chain (Source: adapted from Grant Thornton, 2018)

The ex-works value of the vehicle is typically around 60-70% of the retail price. That is, distribution and sales can account for 30-40% of the final price. Distribution can be via captive or independent logistics companies. These deliver to National Sales Companies who under take PDI (Pre-Delivery Inspection). The retail structure is usually single tier, but in some cases there are second or third tier of smaller dealerships or service-only facilities.

The value chain has remained broadly stable for at least 20 years following the adoption of lean production approaches in the automotive industry in the 1990s. However, the wide changes discussed in section 3 around the CASE concept, allied to a longer-term shift towards circular production, will entail significant changes both in the structure and the membership of what will become a 'value circle'.

The impact of car sharing on the traditional automotive value chain has been minimal so far, as discussed in D3.2. That is, car sharing has not been on sufficient scale to make a difference to production or sales volumes, or the design of cars, or to the operational processes of the supply chain. The introduction of car sharing fleets has mostly involved the allocation of a small proportion of the usual output from the vehicle manufacturers. Where new suppliers have been brought in is in terms of software (e.g. to provide mobile telephone apps and back office systems) and, in the case of EVs, charge points. Apart from some dedicated schemes such as Autolib, no 'unusual' practices (such as design for service revenue) have thus far been entered into by the value chain to support car sharing. The relationship between car sharing and the automotive value chain is discussed in section 2.1.

The only discernible existing impact is on franchised dealerships (and manufacturer-owned dealerships) in those few instances where car sharing is operated from the dealerships. There is no hard data on the number of vehicles involved or on the financial impact, but given that these schemes are few and small-scale, it is assumed that the overall impact on the dealerships is also small. The impact on the post-manufacturing element of the value chain is greater than on the component and material supply side, at least to date. This issue is discussed in section 2.2.

With the potential to be used more intensively, cars in sharing schemes may be scrapped after a shorter time period than has been the historic average for the market as a whole. Again, robust comparative data is missing on this point, but as discussed in D3.2 the link to remarketing is important. Hence in those car sharing schemes owned by vehicle manufacturers it is to be expected that the vehicles will be retired from the car sharing fleet relatively early (say after 12-24 months) to protect residual values. This potentially has important implications for the issue of fleet renewal, the incorporation of new technologies, and for End of Life Vehicle recycling. As is discussed in section 2.3, such issues become more prominent when EVs are considered as part of car sharing fleets.

2.1 Car sharing, car design and the supply chain

The automotive industry has been able to adopt automation and the digitisation of processes to drive down costs and thereby preserve profitability. These measures have been augmented by the pursuit of economies of scale through multi-brand platform strategies, and by mergers and acquisitions such as the creation of the Renault-Nissan alliance. It is illustrative that Renault-Nissan claimed 'synergy' savings of at least €5.5 billion in 2018 as a result of the alliance, in product design, procurement and other activities.

There is a strong argument to be made in support of the idea that **cars intended for use in car sharing schemes should be designed for this purpose**. It may reasonably be expected that shared cars will be used more intensively, and probably with rather less ‘care’ than privately-owned cars. It may also be expected that creating multiple different and bespoke versions of cars, with attendant optional extras, has rather less value for car sharing schemes where more anodyne vehicles can appeal to a wider range of users. Optional extras and more highly specified vehicles usually result in faster depreciation rates, so user costs will be higher if the vehicles are unnecessarily complex or expensive. Typically, mass-market cars are designed to be used by a diverse range of owners with diverse (and changeable) requirements. **However, with annual volumes of new car sales into car sharing schemes being so low there is scant incentive to design and build dedicated vehicles**. To the end of September 2018, no such practices have been adopted with respect to traditional rental cars, a much larger and more enduring market than that for car sharing. That is, because car sharing is a ‘residual’ market the schemes must perforce use vehicles designed and equipped for the traditional range of buyers, either for new cars or used.

There are **two significant examples of cars being designed for car sharing**, along with the introduction of new entrants and new relationships in the supply chain. Both have ended in commercial failure. The first is **Autolib** (Wells and Nieuwenhuis, 2015). The second is the **MIT / Hiriko car** (Freyer, 2015). Whether these failures are attributable to design is a debateable point. Ultimately car sharing is a product-service package. Success or failure may be attributed to one or both of the product-service package.

2.1.1 Autolib

Autolib was run by the Bolloré Group. While traditionally outside the automotive industry, a key interest for the Group was lithium metal polymer (LMP) battery technology for which they hold all the patents. The battery division of Bolloré Group, Batscap has two battery factories: one in Quimper in Brittany; and a second in Montreal, Quebec. Initially, Bolloré approached car manufacturers in 2002 with their LMP technology but without success. In 2004 the company then partnered with CeComp in Italy, who developed the car, which in turn was designed and built by Pininfarina as a subcontractor to CeComp, using Batscap batteries. The so-called ‘Bluecar’ had a 250km range (urban cycle), 150km on mixed cycle, four seats, and required eight hours for a full charge (2x16amp can reduce charging time from eight to four hours). The chassis is a combination of steel and aluminium, the body panels are aluminium, with some plastic panels (e.g. bumpers).

Bolloré won the Autolib tender in early 2011 with this vehicle, the Bluecar. The company was able to combine the vehicle with its own in-house data management and automated interface terminal maker IER, which is a world leader in terminals for public services (e.g. automated check-in at airports). IER provided the access card, charge points, kiosks (where you can sign up), operations

centre, and in-formation management. It's technology also kept track of cars through both GPS and via the charging points. Bolloré was also able to use Polyconseil – its own in-house telecoms consultant. Hence Bolloré had a neatly intersecting set of competencies to provide both the vehicle and the management of the system. These competencies make a difference, both to the overall value proposition and the success of the scheme. In particular subscribers (and those wanting to subscribe) can interact via a screen or via telephone to obtain help and information.

The failure of the Autolib scheme cannot only be ascribed to the design of the cars. However, technical weaknesses with the battery technology, along with the apparent vulnerability of the cars resulting in higher rates of maintenance and service, did not help. The Autolib case is discussed more fully in D2.2 and D3.2. Investigations into the failure of Autolib are underway as this H2020 project progresses. Doubtless much will be learned. However, the important point to note here is that whatever the various multiple causes of the collapse of the Autolib scheme, **car sharing operations on this scale are inevitably going to be complex to create, manage and maintain**. This in turn means that success is not a simple matter of 'building a better mousetrap'.

2.1.2 Basque / MIT Hiriko

The Hiriko car was officially launched in 2012 at an event in Brussels. It was based on a design by the Massachusetts Institute of Technology called CityCar, which comprised a two-seat, folding electric vehicle. It had a door at the front, and so could be parked in such a manner that drivers and passengers could avoid stepping into traffic. Being able to fold the car meant that multiple vehicles could be stacked together, almost akin to supermarket trolleys. In 2008, a consortium of small companies in Spain got together to bring to reality the CityCar concept. Given the emerging global recession, the concept (thereafter named Hiriko) was seen as simultaneously providing innovative, sustainable mobility and new employment for the Basque region.

According to Freyer (2015) the Spanish government pledged some $16 million, and the Basque local authorities gave about $2.2 million. The European Union also devoted millions from a European social fund, for a total Hiriko budget exceeding $80 million.

Unfortunately, thereafter the project collapsed amid claims of misappropriation of public funds. The consortium's parent company, Afypaida, went out of business in 2013. It may have simply been that the magnitude of the task was too great, and the resources too small. The team leader at MIT was quoted as saying later:

> *"We realized that perhaps the ideal urban vehicle is an ultralight-weight one-person, three-wheel vehicle that's bike-like, not carlike. It operates on bike lanes, not roads ... and uses very inexpensive sensing and processing, rather than very expensive systems on highway-speed autonomous vehicles...If you have a shared fleet of vehicles ... that*

serves a population appropriately at rush hour, then you have excess vehicles off-peak. So, we transform the vehicle to move goods autonomously — packages."

This is an illustration of an underlying problem: that **concepts and technologies can become or seen to become obsolete when there is a rapid rate of change**. The development of concepts into products and then mobility services takes years, and inevitably the constituent technologies become frozen in time.

2.1.3 Other design concepts

Others have been tempted by the car sharing market and offered up visions of the future. An example is the German Tier 1 supplier Continental AG. In 2017 this business offered up the (virtual) concept vehicle BEE, a shared, connected, autonomous and electric two-person vehicle (Continental AG, 2017). According to the company press release:

"BEE (short for "Balanced Economy and Ecology mobility concept") is one of Continental's comprehensive visionary solutions for individual mobility in the urban environment. The BEE is designed as a vehicle for one or two people. It is electrically powered and buzzes around at speeds of up to 60 km/h. It can easily cover a distance of more than 350 kilometres every day. Without fuss and within a matter of minutes, it travels to your location when you summon it with your smartphone. It is designed to ensure tailored, stress-free and comfortable travel in the city of the future."

The proposition is that multitudes of these vehicles could effectively merge private and public transport. As the company claims:

"Continental's plan is to see thousands of BEE vehicles forming a swarm of autonomous, electrically operated vehicles in different sizes and with different features. After all, BEE is designed to be a form of public transport that really is for everyone. It adapts to its passengers, both young and old, and with or without physical disabilities. Anyone can summon the right BEE to wherever they are. BEE transports everyone, changing to suit their individual needs."

Utopian visions are not unusual in the automotive industry. A more prosaic explanation may be that Continental wanted to create a high-impact showcase for their portfolio of technologies that could enable this vision, rather than compete with the vehicle manufacturers that are their main customers. The Continental AG press release goes on to say:

"Continental brings with it a vast range of technical expertise, making it the ideal partner for the mobility of tomorrow. For example, ContiTech engineers contributed

> *ideas to the BEE concept – from innovative air springs to transparent interior materials offering that all-important ride quality and comfort. Interior experts have invested a great deal of time and energy in designing secure connectivity solutions and user-friendly machine interfaces. The Powertrain engineers are developing the drive and charging technology. Chassis & Safety developers are working on autonomous driving systems, while our tire specialists are developing intelligent tires for the BEE that contain a proportion of dandelion rubber ("Taraxagum")."*

While this concept does show that some radical changes are technically possible, or will be in the future, there are plenty of constraints. Suppliers in the EU like Continental AG or Magna have a substantial portfolio of technologies that could be brought to bear to make these new mobility visions come to pass. That is, tier one companies have individually or collectively the ability to design, build and deploy radical vehicle concepts suitable for car sharing. However, these businesses also derive the majority of their income from the existing vehicle manufacturers. Such concerns may make it difficult for leading automotive industry suppliers to compete with their customers. Furthermore, proposals like this can readily come up against the existing (mass) public transport system operators, whose markets may be undermined by this new form of mass individual mobility.

A related concept in China is called the Micro Public Transport (MPT) Program established by Kandi (CNN, 2016). The cities include Hangzhou, Shanghai, Chengdu, Nanjing, Guangzhou, Wuhan, Changsha, Changzhou, Rugao, Kunming, Tianjin, Jinhua, Chongqing, Haikou, Shenzhen and Xiangtan. The Company launched the MPT program in the second half of 2013. According to the company:

> *"The Micro Public Transportation program is a unique business model specializing in the hourly sharing and leasing of electric vehicles (EVs) as an extension of public transportation, and is supported by the government's dedication to developing the EV industry and emerging cities in China. We believe the expansion of the MPT program is one of the key engines for Kandi's future growth, which will further enhance our competitive advantages in the EV market."* (Hu Xiaoming, Chairman and Chief Executive Officer of Kandi).

Similarly, there has been some innovative work on the design of ride sharing vehicles. While car sharing and ride sharing are distinct practices, there is no particular reason to assume that in the future car sharing and ride sharing could not be combined. At present, the main factor militating against design for car sharing is that using existing model ranges helps to improve economies of scale in manufacturing.

An example of design for ride-sharing is that of Ideo (Smith, 2017). The concept is illustrated in Figure 2.

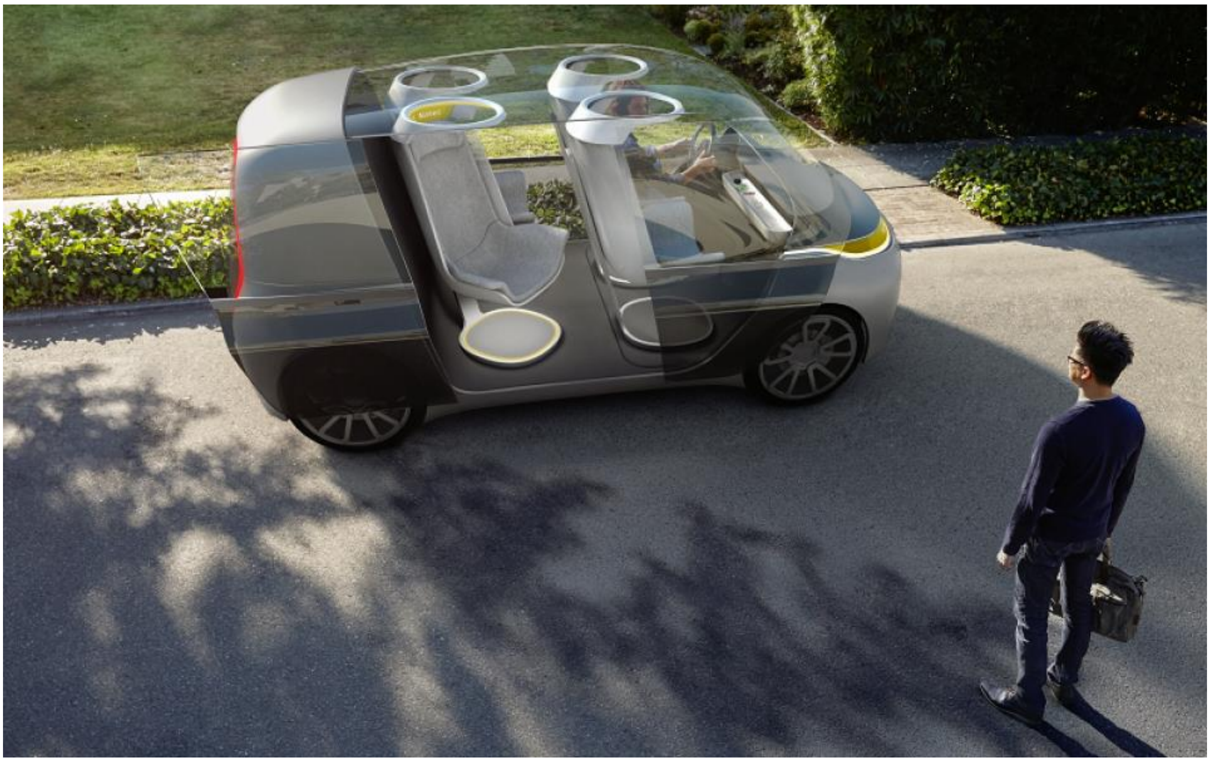

Figure 2: The Ideo ride sharing concept

In the Ideo, each seat pod is equipped with noise cancellation technology. This is almost an extension of the common practice of individuals in social environments (public transport; walking in public areas, etc.) wearing headphones and being virtually connected rather than physically connected to their immediate environment. According to the company, contemporary cars are not designed for sharing and this limits their appeal. According to the company:

> *"Most cars are only used for a small portion of any given day. When they are used, it's mostly by a single driver. They're an expensive, inefficient and under-used resource, and by taking up so much space, they put a real strain on our cities. Our design allows owners to share rides when using their car and rent it to other people when they're not, vastly reducing the cost of vehicle ownership."* (Luis Cilimingras, managing director of Ideo London)

In this vision therefore, the cars are designed to suit a peer-to-peer sharing system, but other business models would be possible with fully autonomous systems in place.

An earlier concept was shown in the EDAG Light Car Sharing Concept in 2012 (Tuvie, 2012) which is illustrated in Figure 3.

Figure 3: The EDAG Light Car Sharing Concept

In this electric vehicle concept there are six folding seats arranged in two rows of three, with two large access doors. The interior flexibility is useful for holding extra luggage, shopping, or a child's pushchair. An interesting feature is the lack of storage surfaces or elaborate interior trim, to avoid unnecessary dirt accumulation.

2.2 Car sharing, car retailing and support, and the franchised dealership networks

Car sharing, but more largely, new shared mobility solutions may have an impact on the (franchised) dealer networks. According to PSA, referring to a Google Auto 2017 report, visits to dealerships have decreased by 40% in Europe (PSA). This is mainly due to a couple of reasons: firstly, the time spent in the dealership to complete a purchase is considered a top frustration (Autotrader, 2014) while satisfaction is highest within the first 90 minutes; secondly, online shopping with improved websites provides all the searched information and proper models' comparison. About 90% of customers do online research before buying a new car, and a surprising 21% do not try the

future new car before buying it. As other industries become more customer-centric, creating a new retail experience is mandatory for dealers in a reshaping automotive industry.

If car sharing exponential growth will be confirmed in the next few years, it will probably lead to decreased individual vehicle ownership. Car sharing providers continue to propose more and more convenient rental packages. Car sharing members may consider not buying a vehicle (new or used), so reducing the number of cars in their households. Additionally, several car sharing services are balancing the "market" with different and enlarged fleets (that is, extending beyond offering only 1 car segment). **Car makers can mitigate car sharing impacts by establishing their own car sharing programs** (ex Car2Go, DriveNow, Emov, or the more recent VW WE just to cite a few), **while dealers are expected to be negatively affected in all business areas**: new cars, used cars, and aftersales.

To what extent will car sharing (and digitalization of automotive market) diminish dealership networks? What are the capabilities that today's automotive retailers must develop to evolve their business for the long term?

Consumers are currently enjoying lower switching costs, and a greater access than even to information and to new shared mobility services. Consumers are moving from an asset purchase to consuming mobility solutions. Also, when it comes to making car purchase decisions, Generation Y drivers value customer experience three times as much as vehicle design. Millennials do their homework before buying comparing all solutions the city and local market propose: from long-term renting programs, car sharing, ride sharing to car purchase. Another bad news for dealers is that 'Baby Boomers' (those born between 1946 and 1964) are getting older: they are currently representing the largest share of car sales.

For many traditional retailers responding to an increasing consumer demand for a more satisfying experience demands a significant reorientation. Today's customers insist that their retail interactions be tailored to their needs.

According to our view (GM GPS Turin), **automotive OEMs should support their dealership networks throughout an agile supply chain that can help in anticipating and meeting customer demands**. Also, the (franchised) dealership network must adapt and familiarize themselves with the new context as huge changes are required to better satisfy new customized and tailored mobility needs.

Dealerships have several possibilities in reimagining of what it means to be an auto retailer. As the mobility market is offering new solution from point A to B, the dominant customer value drivers become the ability for customized configuration and personalization. The cabin becomes a multipurpose space (from living to office) during trips or commuting: a so-called third living place

after houses and offices. Several car makers have already proposed their concept cars: examples are Renault SYMBIOZ, Mercedes F015, or Toyota e-Palette shuttle. In this scenario, the customer is now becoming a contributor of mobility trends and dealers need to be ready to analyse (and act) almost in real-time as low margins and reduced switching costs for users may threaten the business. The customization and integration of customer preferences, in terms of connectivity, may help in retaining the customer and excelling in the value proposition.

Figure 4: Renault SYMBIOZ concept car (Google Images)

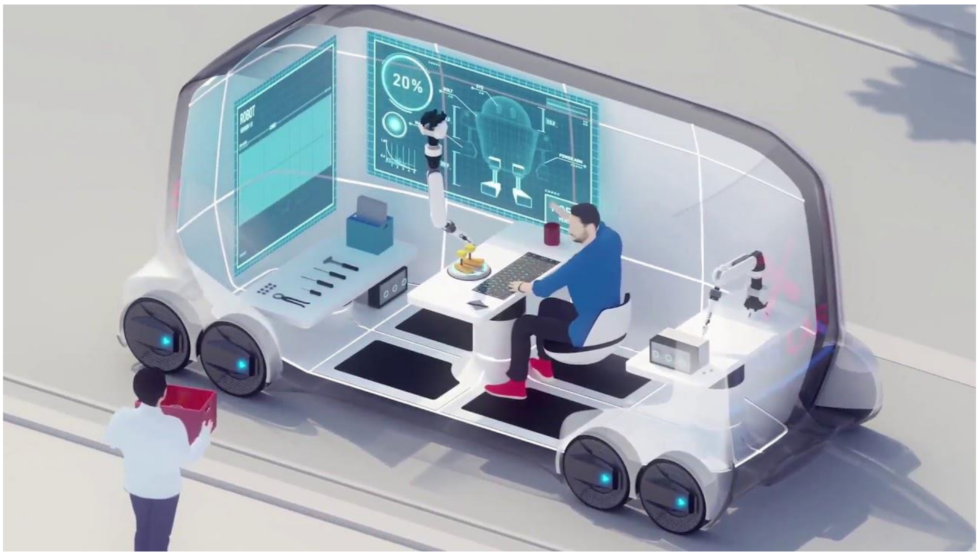

Figure 5: Toyota e-Palette Concept (Google Images)

Dealers should transform their showroom into new experience shops for a customized and optimized customer experience, an advanced form of the current Tesla stores, combining online and in-store guidance with few models available, but with new 'live and drive' test experiences.

Another option for dealers is to become the focal point of customer service for shared mobility providers. Being the customer service for car sharing users for an instantaneous support can increase the value perception of that service. Being on site can lead to value stream

diversification. In addition, several car manufacturers propose both short-term and long-term rental programs including BMW (DriveNow and Access), GM (Maven and Book by Cadillac), Daimler (Car2Go and Mercedes Flexperience), Porche Flex Drive, Care by Volvo, and so on. Vehicle manufacturers and franchised dealers should integrate their strategies into a unique Customer Relationship Management platform creating a horizontal data aggregation capability. As manufacturers' departments and dealers already collect huge amount of data of connected car, customer, vehicles and other services (from sales, marketing, purchasing and dealers' database), few companies integrate all this data into the retail process and a silos structure is normally preferred.

Information about personal mobility could be a cornerstone for successful manufacturers and their (franchised) dealer network moving forward: the value is on how that information makes services more valuable, reducing time and costs.

The most immediate challenge for dealers is represented by the rise of pay-per-use mobility solutions. Investment of infrastructure, trainings on data management, and new "selling" approaches are mandatory for dealers that want to survive.

2.3 Car sharing and End of Life Vehicles

Car sharing is not directly related to concerns over End of Life Vehicles at present. As observed in D3.2 car sharing currently follows an ownership pattern similar to other categories such as corporate fleets, and vehicles on car sharing fleets are sold on before they reach the point of being scrapped.

This situation may change if car sharing becomes an established and large-scale phenomenon. It is likely that car sharing fleets will be used more intensively than is the norm with privately-owned vehicles, and this in turn may accelerate the rate at which the vehicles are degraded and eventually retired. There may be some policy advantage to such accelerated retirement, because the net consequence will be that fleet turnover is faster, allowing new technologies to penetrate the total fleet of cars in use much more quickly. In turn, this faster penetration of new technologies can result in the faster achievement of key policy targets such as toxic and carbon emissions reductions.

Scrappage incentive policies have been used in the past by governments and by vehicle manufacturers, mostly to boost sales at times of economic stress. For example, during the 2008-9 global recession many governments in the EU and elsewhere introduced such schemes where consumers were offered an incentive to scrap an 'old' car, and purchase a new one. The definition of 'old' varied, as did the scale and duration of the incentive scheme. A typical example is the scheme operated in the UK. The government scrappage scheme (Voluntary Scrappage Scheme or VSS) introduced during the 2008-09 recession as a market stimulation measure resulted in 400,000 cars

being scrapped (Butcher, 2018). Announced in the 2009 Budget, the VSS offered up to £2,000 for owners of cars more than 10 years old to scrap the car and purchase a new one. Vehicle manufacturers had to contribute £1,000 to each scrapped car. This scheme was based on the age of the vehicle rather than its condition or the type of engine or emission standard employed. The scheme also required that vehicles be scrapped rather than re-sold.

The high uptake of EVs on car sharing fleets will be important in the medium term because at present the infrastructures and processes needed to recycle battery packs from EVs are not well established. There is no UK plant able to process battery packs from scrapped EVs. Experimental facilities are under construction in some locations. For example, a new plant has been established in Japan by 4R Energy Corporation, a joint venture between Nissan and Sumitomo (Loughran, 2018). The plant will start with selling rebuilt replacement lithium-ion batteries for the first-generation Nissan Leaf. The battery packs will be sold in Japan for ¥300,000 (£2,015), half the price of brand-new replacement batteries.

> *"By reusing spent EV batteries, we wanted to raise the (residual) value of EVs and make them more accessible."* (Eiji Makino, CEO, 4R)

Umicore operates a pilot plant with a 7,000-tonne capacity that can process some 35,000 electric vehicle batteries a year. Other pilot plants include Accurec which has a 1,000-tonne capacity facility for recycling car batteries at Krefeld in Germany.

Car sharing uptake could therefore be a useful stimulus both to the increased use of EVs and, thereafter, to the transition towards circular economy practices. Many governments and policymakers are interested in the scope for the circular economy to contribute both economic growth and reduced new material consumption (i.e. to achieve a decoupling of wealth generation from resource exploitation). The precise manifestation of the circular economy in the future is highly uncertain.

3 Car sharing and CASE: The emergent automobility industry

The emergent world of automobility services is typified by the Daimler strategy of "**Connectivity, Autonomous, Sharing, and Electric**" **(CASE)** (Daimler, 2016) but transition is fraught with complexity and risk (Viereckl et al., 2016). Apple has reportedly experienced immense difficulties, with its Project Titan riven by internal management strife and a growing awareness of the difficulties of car manufacturing (Macrumors, 2016). The reports of the problems encountered by Google are strangely similar (Curry, 2016). Tesla, despite showing that it is possible to be a 'new entrant' into the global automotive pantheon, has also struggled with profitability and with some high-profile incidents with the Autopilot system. Meanwhile, incumbent vehicle manufacturers' electric vehicle sales don't match expectations (see for example Loveday, 2016), and the manufacturers have proven rather more cautious about the introduction of autonomous technologies. Building new quasi-diagonal bridges across industry is not easy: the example of BMW and Apple is illustrative (Taylor and Love, 2015). It is illustrative that Daimler CEO Dieter Zetsche said:

> *"Google and Apple want to provide system software for cars and bring this entire ecosystem around Apple and Google into the vehicle. That can be interesting for both sides… (but) We don't want to become contractors who have no direct content with customers anymore and supply hardware to third parties." (Cremer, 2015)*

Much of this transition is uncertain, from the underlying technologies to the expected demand (Hinkeldein et al., 2015) but the structural and business model innovations already evident with respect to EVs (Weiller et al., 2015) are being compounded by the additional demands of connectivity, automation and sharing.

There is a tension between the need for consolidation and standardisation in traditional vehicle manufacturing, and the need to cope with an accelerating process of market fragmentation that is accompanying the transition to automobility. Industrial restructuring has traditionally taken four major forms: diversification into essentially unrelated domains; the development of new internal competencies; vertical integration into the supply chain or distribution chain; and horizontal integration whereby competitors are absorbed into larger entities to generate economies of scale. An example of diversification is that of Toyota, where the company also makes houses. An example of new internal competences is that of BMW creating the ability to press and join carbon fibre panels in high volume. In recent years the vehicle manufacturers have mostly focussed on vertical disintegration (to release the resources to focus on core competencies), but in terms of vertical integration examples include the Daimler, Audi and BMW purchase of the HERE digital mapping

company. Horizontal integration has occurred periodically in the industry at various tier levels. For the vehicle manufacturers the purchase of Volvo by Geely would be an example. Digitization has, however, added a further form of industrial restructuring in which the core product (in this case, cars) is undergoing fundamental alteration as a technology and consumer proposition, and at an unprecedented pace. As an industry, this means that the automotive sector is increasingly concerned with re-defining what is 'in' the sector and what is not. That is to say, the boundary edges of the sector are getting blurred. The new industry is often portrayed as an emergent 'ecosystem' of automobility services, as if it is a cohesive entity, but in practice the boundaries of the existing automotive world overlap with a growing number of other worlds in electricity generation and distribution, in artificial intelligence, in mobile communications, in big data, mapping and real-time information provision for example (Schulze et al., 2015). Companies facing this uncertainty and turbulence may seek a range of 'protection' strategies; Pinske et al. (2014) identify 'collaboration-integration' as one such strategy, but do not elaborate greatly on how such collaboration-integration is to be achieved. For the vehicle manufacturers and their leading suppliers that constitute the core of the current automotive industry there is the twin challenge of how to maintain the existing business (invest in new plants and models; close down plants no longer needed; manage existing supply chains; retain brand positioning, etc.) while simultaneously deciding how far to proceed with these burgeoning new requirements that come with the transition to automobility, with whom, where, and on what basis.

New portfolios of competence and business model innovation will be required, both from traditional automotive industry players and new entrants, with considerable scope for synergies. Experienced automotive industry players that understand the cost pressures in the industry are often best-placed to leverage new technologies into mass production, but may need to access new skills and assets in these technologies through acquisition, alliances or organic growth. It is argued that one consequence is that traditional strategies of vertical or horizontal integration within an industry are of decreasing utility. In effect, automobility services built around electric, connected, shared and autonomous vehicles arise out of and demand the confluence of two or more industry sectors as the industry boundaries dissolve. In this sense themes such as autonomous cars are not simply definitions of a product, but also a process which can be understood as seeking to bring together disparate entities (MacDuffie, 2013).

One way of managing this process is to create diagonal relationships across industry sectors. Thus, diagonal integration may be defined as the direct acquisition of new competencies in any part of the emergent automobility services ecosystem. These integrational relationships are not easy: the example of BMW and Apple is illustrative (Taylor and Love, 2015). In the BMW and Apple case, both companies had strong brands and core competences, and so it was impossible to reconcile the two

sets of ambition: would the result be a BMW with Apple technology, or an Apple car assembled by BMW? Alternatively, traditional rivalries may be set aside as in the case of BMW, Mercedes and Audi co-purchasing HERE from Nokia. Quasi-diagonal integration (QDI) may be defined as the less stable, more expedient (and possibly lower immediate financial risk) version in that the integration process falls short of outright ownership, but is more than the mere purchase of components or services. QDI is thus one mechanism by which network innovation may be achieved (Johansson and Deniz, 2014). This is because QDI relationships emerge out of and are part of the process of creating shared cognitive framings of emergent phenomena and may be expected to be more prevalent when new contexts or requirements are present. The cognitive framing for emergent technologies such as those required for the autonomous car, or shared car, or even electric car, is thus understood as the mechanism by which innovation can be orchestrated within a network through the medium of QDI relationships.

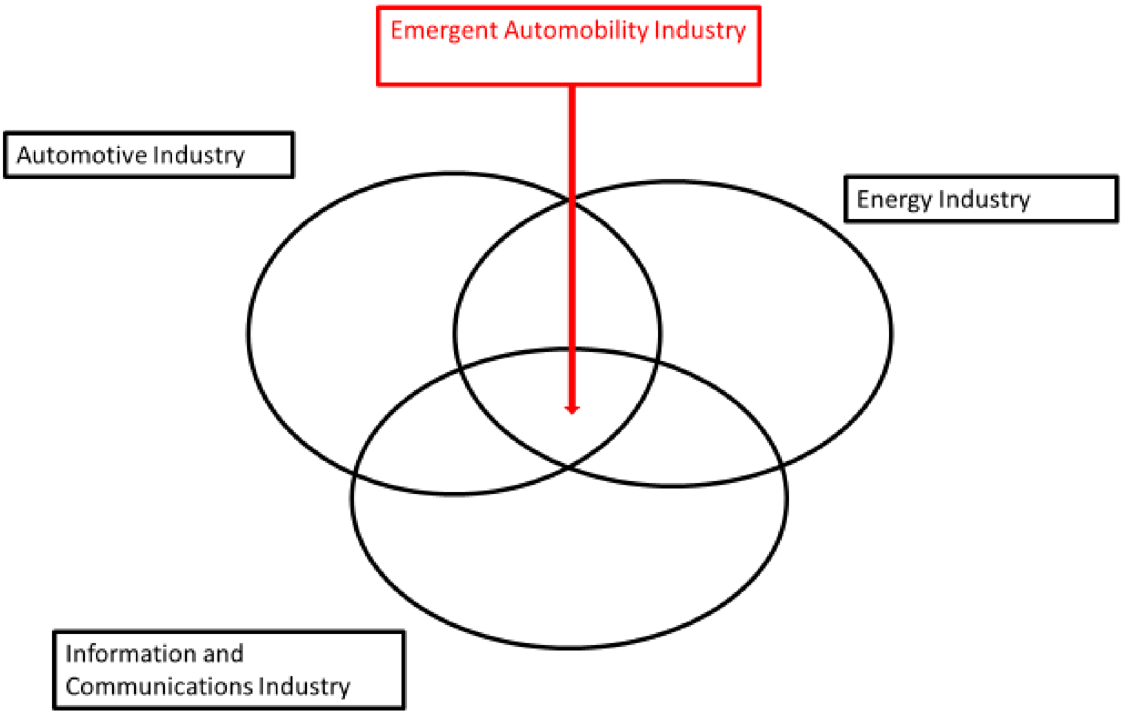

Figure 6: The emergent automobility industry

This section provides evidence of the relationships entered into by vehicle manufacturers with e.g. mapping companies, search engine companies, public transport authorities, and others involved in dissolving the boundaries of the sector. More detailed case studies of Volvo and Mobileye are provided to illuminate the themes.

3.1 The CASE concept

The CASE concept at its most fundamental **shifts the industry from a linear business model to a circular business model, and from providing cars to providing mobility**. It is useful to understand this shift in the context of the prevailing generic automotive industry business model.

The automotive industry business model evolved out of a set of specific circumstances prevailing in North America in the period 1900 to 1930, from where over time the model was replicated with some adaptation around the world. There are three core innovations that shaped the business model. These are:

- The production and assembly system established by Ford, characterised by the moving assembly line, short cycle time tasks, and standardised components;
- The all-steel pressed and welded body developed by Budd, which enabled robust vehicle architectures that could be painted;
- The vehicle branding and marketing systems established by Sloan at GM, characterised by the provision of consumer finance, trade-in of used cars, and the idea of the annual model change to keep demand high.

The generic automotive industry business model is founded upon three key innovations arising in the 19th century: the Ford moving assembly line and related concepts (such as standardised parts; short cycle times); the Budd all-steel vehicle and related concepts (such as painted vehicle bodies); and the Sloan concepts of creating a range of brands and models and related concepts (such as credit for car purchases; used-car trade-ins; annual model cycles) (Clarke, 1996; Marchand, 1991; Nieuwenhuis and Wells, 2007; Raff, 1991). Over time, there has been a process of convergence and consolidation of this business model, as well of change and refinement.

This structure allowed the capture of economies of scale, which in turn resulted in the eventual closure of many hundreds of artisan and small-scale manufacturers in the US and Europe. The result was a capital-intensive industry, with high levels of vertical integration operating large manufacturing facilities. In turn, factories required spatially distributed sales outlets to reach potential customers, and to support them in the post-purchase period. The result was a network of franchised dealers.

Car companies primarily created revenue through the sale of new cars, the associated finance packages, and the maintenance and spare-parts provision needed to keep the cars in circulation. However, typically after three years or so cars tend to 'drop out' of the official franchised dealer network and into the independent sector. Thereafter, manufacturers have historically had scant interest in the fate of their vehicles, up to and including when they reach the end of their useful

working lives. The legal obligations regarding recycling rates (as in the EU End of Life Vehicle Directive) even now tend to be subcontracted out to third part suppliers.

Many other companies could profit from the sale of cars, however. Thus, over the lifetime of the car these other companies (insurance; fuel; independent used car traders; parts producers; etc.) could earn revenues from the vehicle in use, even when the vehicle manufacturers did not earn this revenue.

The CASE concept has the potential to challenge this fundamental model, although it is as yet uncertain how far this concept will go towards a fully circular business model. CASE has the impact of taking the vehicle manufacturer further into the in-use phase of the product in terms of revenues. It changes the focus from the sale of the car as the most significant source of revenue.

3.1.1 Connected

Importantly, developments in autonomous and connected cars may resonate with the contemporary pattern of individuals who are physically isolated in social space, but widely networked in virtual space.

> *"First, it's a race to determine who will own these revenue streams, whether it's Silicon Valley, the utilities or the manufacturers who theoretically own the relationship with the customer. The second aspect is all the patterns we can draw from the data that's being collected. I think at the moment, no one really has a clue how we will leverage it all."* (Berthold Puchta, General Manager, Global Automotive, Industrial & Chemical Industries, CSC, 2015)

The new brand Lynk & Co. (a collaboration between Geely and Volvo) has deliberately targeted connectivity and collaborative consumption through shared vehicles (Aouf, 2016). The is seeking a ‘premium’ positioning for their customer proposition:

> *"The 01 will be the most connected car in the world: designed for a modern, urban audience who are used to collaborative consumption and all the benefits that this brings... As consumer behaviour changes from valuing experiences over ownerships, Lynk & Co's new model for car usage directly answers to this need."* (Alain Visser, VP Lynk & Co, cited in Aouf, 2016)

One feature of this strategy is to create an open platform that will enable other software authors to create apps for the platform. The cars are opened via radio-frequency identification (RFID). Through the accompanying digital platforms, owners can give their friends, family or other drivers the "keys" to their cars for a specific time. In this concept therefore, there is a deliberate attempt to

allow third-party car sharing operations to use the car. On the other hand, the cars are not yet electric and nor is there an attempt to apply the autonomous technologies that are under development elsewhere in the Geely-Volvo group. The assessment was the BEV technology was not yet of sufficient range and charging times were too long to be useful in multiple-use contexts.

The quest for connectivity is one of the underlying reasons for the erosion of the boundaries of the automotive industry as 'tech' companies seek the application of their platforms such as Apple and Android (Ulrich, 2015). Integration for connectivity has not been simple for the vehicle manufacturers. Alongside concern at losing revenue from the sale of navigation systems, vehicle manufacturers have needed to install and be compatible with both main systems or else alienate a significant potential market. Moreover, it is illustrative that the Audi system lacks a touchscreen for which Apple and Android have been designed. Thus Audi, BMW and others had to redesign items like rotary selection knobs and touchpads for the systems to function correctly.

Connectivity should bring benefits to vehicle owners or users, or at least meet contemporary expectations. In a fully-connected vehicle with high-speed mobile broadband the full benefits of connectivity can only be enjoyed by the passengers if the driver has an active role. In a fully autonomous vehicle the possibilities increase significantly. It is this thinking that has resulted in, for example, the car being portrayed as an autonomous mobile office or party space. Connectivity then brings to vehicle users real-time virtual interaction via the Internet in the manner that can be experienced in the home or the office. Content can be streamed, various forms of networking are possible, searches can be undertaken.

For the vehicle manufacturers and others there are multiple potential benefits from connectivity. Connectivity allows the delivery of value-added services that can both be an additional revenue stream and a source of brand differentiation. Probably more significantly, connectivity will deliver huge volumes of data. This data can relate to the operational parameters of the vehicles, for example then informing maintenance strategies, the supply of spare parts, and the design of future vehicles. Beyond this, the data can provide rich insights into the lifestyles and preferences of those using the vehicles via data analytics.

There are downsides of course. The sheer volume of data that could be generated by full connectivity is huge, and this in turn will require large investments in processing power and software if the value is to be realised. An additional problem area is that of personal data security. Following ongoing complaints against Facebook and other social media sites there is renewed attention being given to how companies hold and use personal data, as well as concerns over data being 'hacked' by third parties. Some users are further worried about external monitoring of their movements, their trip preferences and destinations. If users 'pay' for connectivity via being subject to advertising, this too may cause disquiet and reduced customer satisfaction.

In terms of the wider CASE concept, connectivity is potentially good for car sharing because:

- It helps users book, locate and pay for the cars in a seamless and rapid manner;
- It helps users new to a location with navigation;
- It helps operators track cars and monitor their condition;
- It can be linked to insurance to obtain the best possible rates.

3.1.2 Autonomous

In June 2011 the U.S. state of Nevada passed a law that, for the first time, allowed the operation of autonomous cars on public roads within the state. Just 12 months later came the first registered vehicle, a Toyota Prius equipped with Google's technology. By May 2014 Google had their own vehicle in the public realm, and from that point onwards the contest over autonomous and connected cars was truly instigated (Wells, 2015; CB Insights, 2017).

The term 'autonomous car' is a term that is sometimes used inter-changeably with other terms such as 'driverless' or 'self-driving'. The question of definition is not merely technical, it is also legal. For example, the Google cars have no steering mechanism, so there is no possibility of the 'driver' making steering choices. However, under current US State law in those locations that have licenced the trial use of the cars, the primary occupant must be a qualified driver. It is also the case that there is something of a continuum of assistance for drivers from full personal control over all functions of the car, through to full autonomy with no need for driver input.

In the contemporary situation there are many degrees of 'autonomy', and in fact the introduction of such technologies has been rather more gradual than has been readily appreciated by the wider population. One widely quoted technical definition source is the US NHTSA (2013) that defines five levels of autonomy:

- No-Automation (Level 0): The driver is in complete and sole control of the primary vehicle controls – brake, steering, throttle, and motive power – at all times.
- Function-specific Automation (Level 1): Automation at this level involves one or more specific control functions. Examples include electronic stability control or pre-charged brakes, where the vehicle automatically assists with braking to enable the driver to regain control of the vehicle or stop faster than possible by acting alone.
- Combined Function Automation (Level 2): This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those

functions. An example of combined functions enabling a Level 2 system is adaptive cruise control in combination with lane centring.

- Limited Self-Driving automation (Level 3): Vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The Google car is an example of limited self-driving automation.
- Full Self-Driving Automation (Level 4): The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles.

In practice, other forms of automation have long been present in a variety of cars, including of course automatic transmission; ABS brakes; automatic stability systems and suspension control; cruise control; seatbelt pre-tensioning; airbag deployment; climate control; automatic lights; automatic windscreen wipers; remote opening and locking; automatic boot opening; and more recently developments such as distance keeping radar and self-parking systems. Thus, many cars are at least equipped to Level 2 or 3 in the NHTSA system. It could be argued that the driver remains in complete and sole control of the vehicle with e.g. cruise control, yet such technologies also mark a stage of 'disconnection' between occupant and machine, and hence a trajectory that can in subsequent stages result in the autonomous car. By such means are drivers habituated, expectations are changed, and the qualitative experience changes also. The visceral connection with the car for the driver has been eroded over time, partly due to the above technologies and with resultant improved reliability and comfort. In turn, these changes effectively 'de-skill' driving, at least at the mechanical level.

The main claims advanced for autonomous cars include reduced driver stress, reduced driver costs, increased safety, increased use of the road infrastructure through e.g. 'platooning', more efficient parking, reduced pollution and fuel use, support of shared vehicles (Litman, 2015). It is recognised that some costs will be incurred also. These include increased vehicle costs due to the additional equipment installed, greater risks if e.g. there is a widespread system failure or cars are 'hacked', other security or crime concerns, and reduced employment for e.g. drivers or vehicle repair centres (Litman, 2015). More profoundly perhaps it can be readily appreciated that in combination these technologies largely speak to the 'eco-efficiency' perspective in that they may enable a reduction in the per unit environmental and social costs of automobility, but do little to challenge the primacy of that automobility and hence to prioritise the alternatives. Research by the

International Transport Forum in Lisbon showed that urban mobility could be transformed by car sharing, autonomous and electric vehicles – but to be really effective the entire private-use fleet needed to be removed. In that case, the city only needed 10% of the number of vehicles, and pollution and other problems were reduced dramatically (see https://www.itf-oecd.org/itf-work-shared-mobility).

At the policy level the main (claimed) impetus for autonomous cars lies in the potential reduction in deaths and injuries attributable to car collisions, including those with vulnerable road uses. In addition, this type of technology may be a means to extend automobility to those segments of the population that are currently excluded including the elderly (Engels and Liu, 2011; Gagliardi et al., 20110; Nordbakke and Schwanen, 2014), those too young to drive, or the impaired, currently disbarred from driving cars (Hong, 2011). That is, lack of access to mobility is part of social exclusion (Cass et al., 2005). Hence, **innovations in autonomous cars may enable automobility for more people** (Herriots, 2005; Harper et al., 2016; Wadud et al., 2016). The policy level is somewhat agnostic on whether cars are a commodity, though systems such as that deployed by Bollore in Paris and elsewhere do suggest it. **If autonomous cars are also built as shared cars they will need to come with hard-wearing, repairable surfaces and interiors** – they will not necessarily be the plush cocoons of today – built to a low price and minimal specification for urban duty. Without personal ownership and customisation there is much less incentive for high-cost added 'extras', or indeed as much call for a diversity of suppliers of cars. Moreover, with fewer accidents and combined with the introduction of (more durable) electric cars and more shared cars, the industry faces a collapse in the market for new cars. In this sense the 'nightmare' scenario for the industry is that the vision of automobility presented by Google, as a rather inoffensive but equally uninteresting 'blob' running inconspicuously around our cities, is actually what the future will hold.

For the automotive industry the reduction of cars to mere transport would be a disaster. It is perhaps for this reason that, according to Roberts (2015) Ford has claimed it is 'almost impossible' to sell self-driving cars:

> *"Nobody can predict whether these fully autonomous vehicles will work under all environmental conditions. The Google cars have an issue with heavy rain and snow. Very low sunlight is also very bad because the cameras don't see anything so you need to have some sort of controlled environment."* (Ford CEO, Mark Fields, quoted in Roberts, 2015)

Hence the industry is searching for a pathway that embraces the 'inevitability' of autonomous cars but does so in a manner that also allows for brand transition. A good example is that of BMW. In broad terms the approach is as stated:

"We are moving from The Ultimate Driving Machine to the Ultimate Driver, where technology is making any driver a better driver," (BMW Design Chief, Adrian van Hooydonk, quoted in Ciferri, 2016).

A similar approach is evident with Audi, When the latest A8 was launched in 2017 Audi made some strong claims, but also limited the extent of autonomous applications:

"Today is where the future begins in the luxury class: The new Audi A8 makes its world debut at the Audi Summit in Barcelona. In its fourth generation, the flagship model again sets the benchmark for Vorsprung durch Technik with a new design language, an innovative touchscreen operating concept and systematic drivetrain electrification. The Audi A8 is also the first production car in the world to have been developed for highly automated driving. From 2018, Audi will gradually be taking piloted driving functions such as parking pilot, garage pilot and traffic jam pilot into production." (Audi PR, 2017)

There are concerns over partial and full autonomous technologies. At present, the main concern is that consumers do not necessarily understand the limits of capability of cars that are not fully autonomous. In turn, there have been fatalities associated with the inappropriate use of the vehicles. Doubts about the competence of such technologies also raise questions about liability in the event of deaths, injuries or damage to property. Consumer groups have noted that giving such systems names like 'Autopilot' conveys an unrealisable expectation of performance, and hence some degree of liability on behalf of manufacturers.

More broadly the concerns revolve around the 'fit' of autonomous cars into existing mobility patterns and structures, as well as the impact autonomous vehicles may have on overall demand for personal mobility. It is already the case that autonomous vehicles function better in relatively 'simple' environments in which the potential variability is limited. Hence, autonomous cars are more able to cope in closed contexts (like a campus site or factory floor), or relatively simply contexts such as a motorway. The chaotic conditions found in many urban areas around the world would result in autonomous vehicles simply standing stationary, as the safety systems would not allow the vehicle to move. However, if all other road users are excluded, where must they go to travel? It is clear therefore that the adoption of autonomous vehicles does not in itself resolve the underlying issues of the use of mobility infrastructures. It is doubtful if the exclusion of all other road users would be politically acceptably or practically achievable.

In terms of travel demand, the main concern is that full autonomy would make the vehicle accessible to a much wider proportion of the population, or even to be sent on errands while not having any occupants at all. In this vision of the future, there are large numbers of vehicles with the attendant inevitable congestion, but users do not feel as frustrated because they are not actually doing the driving.

In terms of the wider CASE concept, (Partial or full) autonomy is potentially good for car sharing because:

- It reduces the likelihood and severity of crashes, so protecting users and lowering costs;
- Reduced crash damage also reduces maintenance costs for operators, and reduces unanticipated vehicle downtime;
- It reduces the chances of driving rule violations, and so reduces the management costs of processing legal claims;
- It is especially useful for drivers new to a location or driving situation;
- It expands the potential range of vehicle users and occupants in the case of fully autonomous vehicles;
- It may include some useful 'surprise and delight' features such as self-parking.

3.1.3 Shared

The contribution of sharing to the CASE concept is covered in this entire study, and in the key Delivered reports associated with the research. For vehicle manufacturers, sharing may be complementary to connectivity, autonomy, and electrification – but not necessarily so.

3.1.4 Electric

Electric vehicles have a very uneven penetration rate in EU markets at present. There are varying levels and kinds of government support to consumers to purchase the cars and to install charging points. Moreover, support has been in place for varying amounts of time. As a result, with a few notable exceptions, national markets in the EU and EEA have only a small share accounted for by pure BEVs or by PHEVs.

The situation is changing however. New models with better-performing technologies are being introduced by vehicle manufacturers, while costs are going down. Public infrastructures are also being deployed more intensively, albeit again in an uneven manner and with issues around inter-operability. In 2018 LeasePlan, a company providing finance for vehicle purchase and use, issued a report in which it was claimed that EVs were cost-competitive in Norway and the Netherlands, while in Belgium and the UK, the gap in the total cost of ownership is rapidly narrowing (LeasePlan, 2018).

Country	Petrol	Diesel	Electric
Austria	€538	€497	€788
Belgium	€590	€561	€898
Czech Republic	€416	€425	€800
Denmark	€642	€607	€914
Finland	€630	€637	€955
France	€472	€475	€836
Germany	€515	€489	€788
Greece	€468	€427	€953
Hungary	€393	€405	€597
Ireland	€506	€474	€852
Italy	€667	€628	€986
Netherlands	€604	€686	€705
Norway	€731	€722	€670
Poland	€445	€359	€634
Romania	€353	€363	€890
Slovakia	€442	€416	€955
Spain	€477	€476	€952
Sweden	€631	€568	€770
Switzerland	€557	€516	€800
Turkey	€492	€519	-
United Kingdom	€538	€535	€719
Average	€536	€523	€819

Table 1: Comparative costs of car ownership in selected countries, 2018 (Source: LeasePlan, 2018)

The advantages and disadvantages of EVs have been extensively debated and are in any case subject to rapid change as the technology develops, cost structures change, and the incentive and regulatory context is modified. The perception of Nissan is useful because the business has been in the forefront of EV sales. According to Gareth Dunsmore at Nissan:

"Calculating TCOs needs a new approach. We need fleets to change and evolve their business models, because the TCO of electric vehicles is drastically improved with solar energy. And, of course, you do not take back charge points when you sell an EV. Some of these concepts even hold out the prospect of generating revenue for fleets, with Nissan working with the utility firm Frederiksberg Forsyning, in Copenhagen,

Denmark to explore the opportunities of vehicle to grid infrastructure, which allows electric vehicles to sell electricity back into the grid at times of peak demand and to recharge batteries at times of low demand. They are generating €40 per van per week. That will revolutionise the TCO for a fleet if they are plugging in their vehicles, sharing the leftover capacity in their battery, taking capacity when there's too much wind or solar being produced and getting money for that. Suddenly you can start operating the fleet for free forever." (Gareth Dunsmore, electric vehicle director, Nissan Europe, 2018. Source: Fleet Europe, 2018).

It is worth noting that some vehicle manufacturers have already sought to extend the electrification of the car into the control of the household energy system. Notable in this area are both Tesla and Daimler. It may be that the Tesla Powerwall and related concepts may not be compatible with car sharing. The vision offered by companies like Tesla and Daimler is of integration between electric cars and domestic energy management systems, including the use of renewable (mainly solar) energy sources. In principle, the idea is that the car battery can be used to store energy when there is an excess of supply, or it is cheap, and if need be return it to the domestic system when energy is expensive. Presumably, these systems require that the car, when not in use, be connected to the house to exchange energy at the appropriate moments. If this is the case, then car sharing will reduce the advantages of the home / car energy system.

In terms of the wider CASE concept, EVs are potentially good for car sharing because:

- They are generally easier to drive than a traditional manual gear-change car and hence appeal to a wider range of potential users;
- The powertrain has fewer moving parts making it inherently more reliable, and hence there is less downtime in terms of capacity utilisation;
- It enables car sharing users to enter into zero / low emissions zones, thereby giving users greater freedom of choice than traditional ICE cars;
- They fit against the wider social ethos of some car sharing schemes in that they contribute to good citizenship by being quieter and non-polluting at source.

3.2 Vehicle manufacturers and automobility concepts

At a generic level, the mainstream or high-volume automotive industry has a clearly defined and established business model. Value capture is centred on a product / service package consisting of all-steel vehicle bodies using petrol or diesel engines which are sold to end-users alongside warranty and service provision. Markets are segmented by various classes and types of car, in a bid

to reach different customer types and thereby extract maximum value. Value creation is achieved by the orchestration of in-house capabilities such as the manufacture of vehicle bodies and vehicle assembly, along with procurement regimes that co-ordinate and manage global supply chains and local clusters. Centralised manufacturing operations seeking maximum production economies of scale also necessitate the use of spatially extensive networks of franchised dealers for the sale and support of vehicles.

3.2.1 New entrants and business model innovation

As is shown in Table 2, the boundaries of the automotive industry are potentially being eroded by a range of possible new participants. If this erosion is understood as the wider shift from an automotive to an automobility industry, then existing vehicle manufacturers are just one of the possible participants, which is illustrated in detail from Figure 7 to Figure 14.

Sector	Hypothetical example and basis for participation	Possible contribution
Vehicle manufacturers (existing)	BMW. Existing market recognition and brand; established sales networks. Ability to integrate complex systems into a coherent vehicle. Migrate out of problematic mainstream automotive business.	Integrated carbon fibre body and battery electric traction with 'cost plus' value capture strategy through premium branding.
Vehicle manufacturers (new)	Tesla. Typically combining elements of the new (mostly technological) with established practice.	Creation of new brand identity around novel product and market offerings as transition 'pioneers'.
Aerospace	British Aerospace. Expertise in electronics and software, sensors, network systems, and carbon fibre structures. Diversify out of aerospace / military segments.	Carbon fibre technology; drive by wire; sensors and actuators in integrated systems. Also head-up displays, information hierarchies for drivers, man-machine interface issues.
ICT	Google. Apple. Samsung. Extension of reach into mobile applications. Data management, mapping skills. Consumer brand awareness.	Connected car; autonomous vehicle with real-time mapping capability. Internet of things.
Personal financial sector	Banks e.g. Lloyds. Expertise in management of financial systems for retail and corporate accounts; expertise	Card operated payment systems for 'pay per use' vehicles and EV recharging systems (e.g. Bollore).

Sector	Hypothetical example and basis for participation	Possible contribution
	in smart cards, fraud management, etc.	
Daily rental sector	Avis. Understanding of vehicle finance, discounts, re-marketing. Significant user customer base.	Expertise in vehicle management for large and small users; vehicle re-marketing.
Taxi operators or licence issuers	Uber. May provide early market for alternative technology fleets with tight focus on duty cycles to enable optimisation	Data on performance. Disruptive business model.
Electricity generators	Powergen. Potential market growth in sale of electricity.	Contributions in low-carbon power generation; load / demand management relative to supply.
Electricity distributors	EON; EDF; Ecotricity. Potential to extend retail and corporate customers into EV charging. Ability to manage supply and demand issues across the network.	Understanding of local and temporal loads on the total system. Billing management for customers.
Battery suppliers	BYD (China). Major market opportunity for sale (and resale) of batteries and related systems.	Continued refinement of powertrain core. Possibility of 'Intel inside' strategy.
Electric drive suppliers	Bosch; Axion; Schaeffler. Usually market extension into new areas (see also Bosch interests in electric bicycles for example). Diversify against possible decline in core existing automotive businesses.	Integration of powertrain systems for wide range of applications.
Vehicle charging infrastructure managers	Chargemaster; Bolloré. Management services opportunity to diversify into new market space.	Installation and management of complete networks including membership issues.
Infrastructure equipment suppliers	Rolec. Manufacturing of recharging posts and related equipment. Some are established electro-mechanical equipment suppliers, some are new entrants.	Range of re-charging points for variety of applications.

Sector	Hypothetical example and basis for participation	Possible contribution
Car clubs and other car-sharing schemes including peer-to-peer platforms.	Car2Go, Zipcar. New growth opportunities especially with regard to EVs.	Means to avoid personal ownership of cars. Greater utilisation of the assets; more efficient use of charge / recharge cycles.
City authorities	Paris; London. Interests in improving flow of traffic, air quality, reducing congestion, creating political capital, etc.	Means to avoid personal ownership of cars; provision of local laws, etc. for EV provision. Provision of contracts for electric vehicle service suppliers.
Bicycle / motorbike manufacturers	Yamaha. Diversification of existing business.	Could expand upward into light EV sector. Electric bicycles could displace cars.

Table 2: Typology of potential participants in the emerging automotive regime

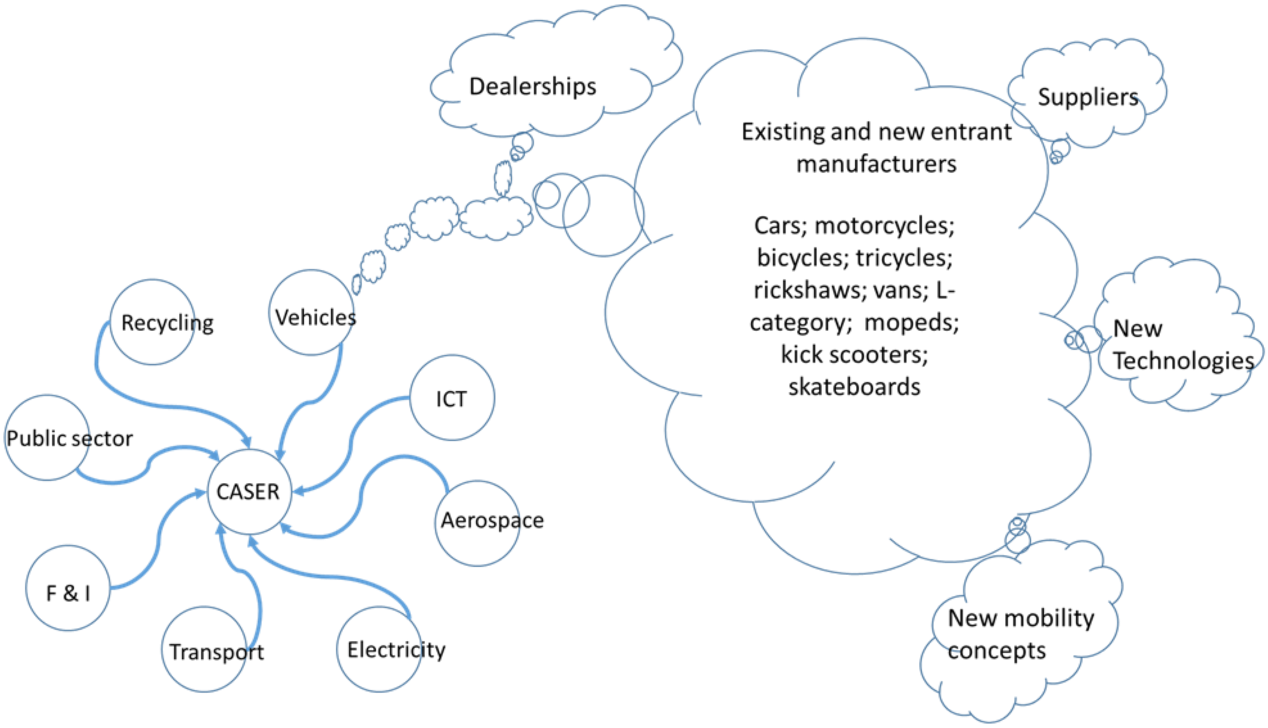

Figure 7: The automobility system (vehicles)

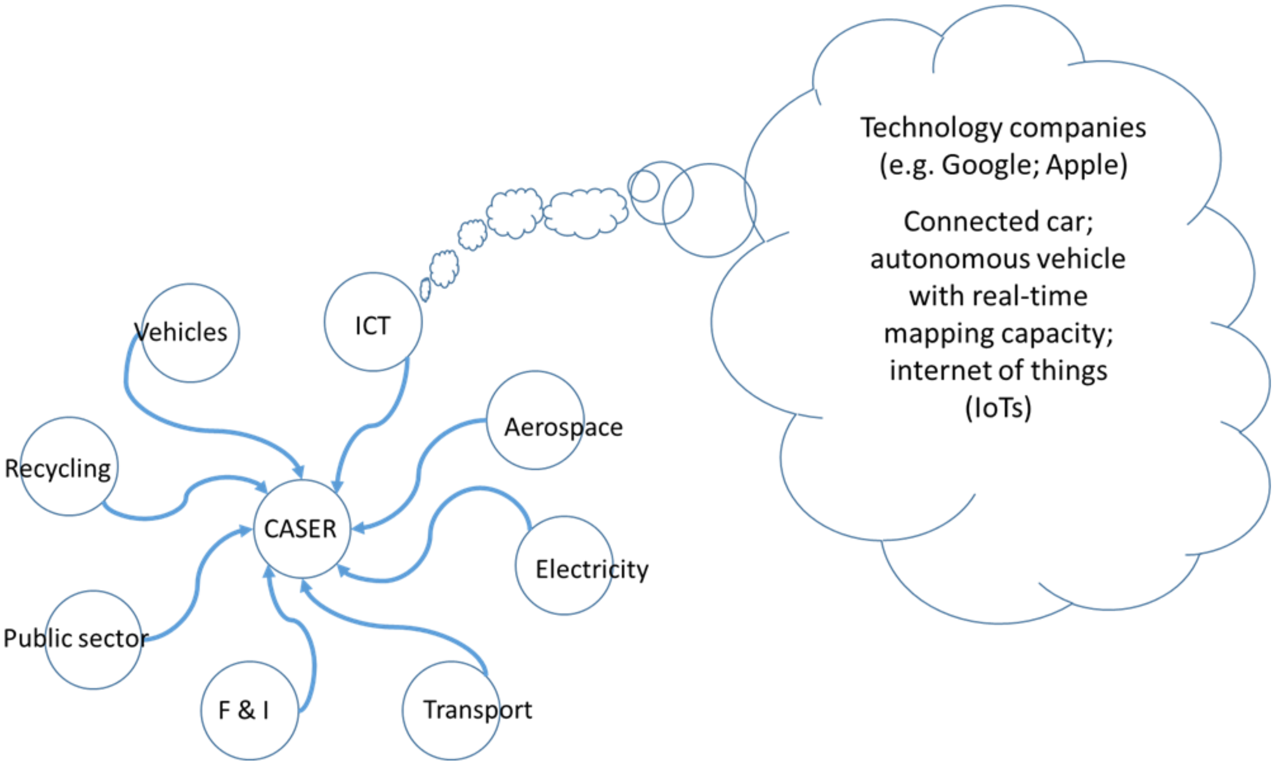

Figure 8: The automobility system (ICT)

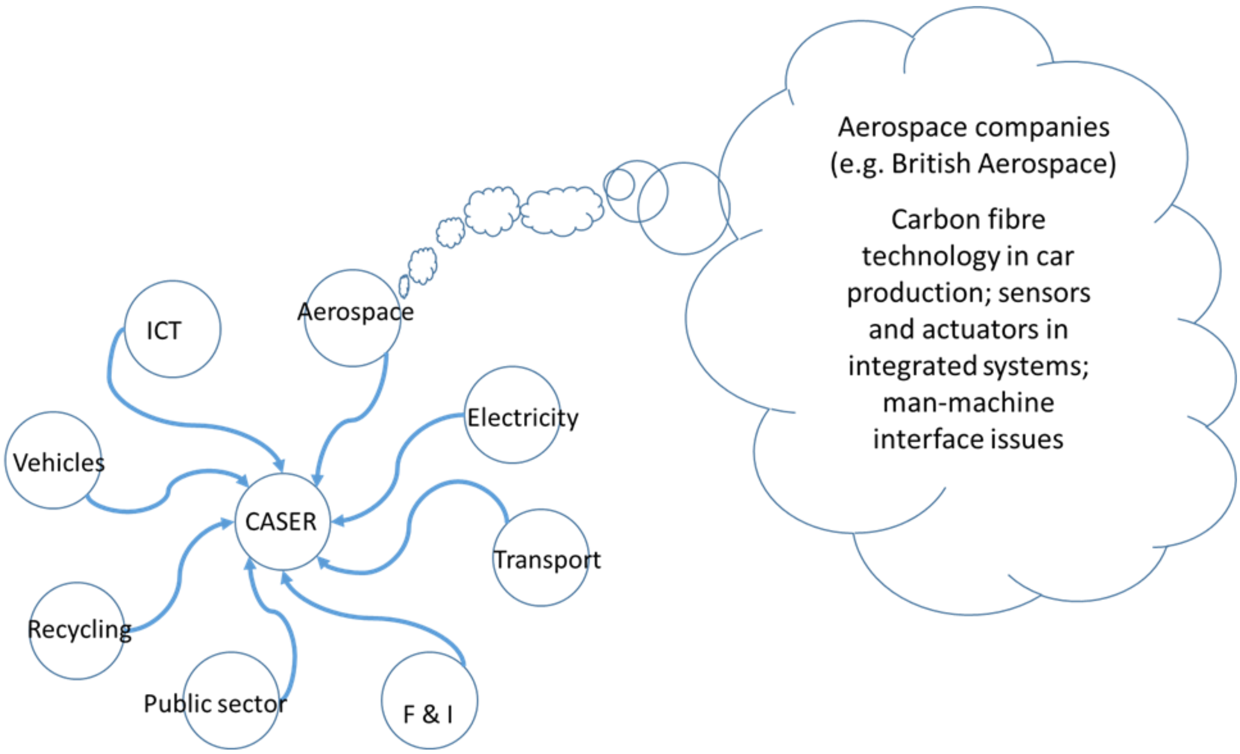

Figure 9: The automobility system (Aerospace)

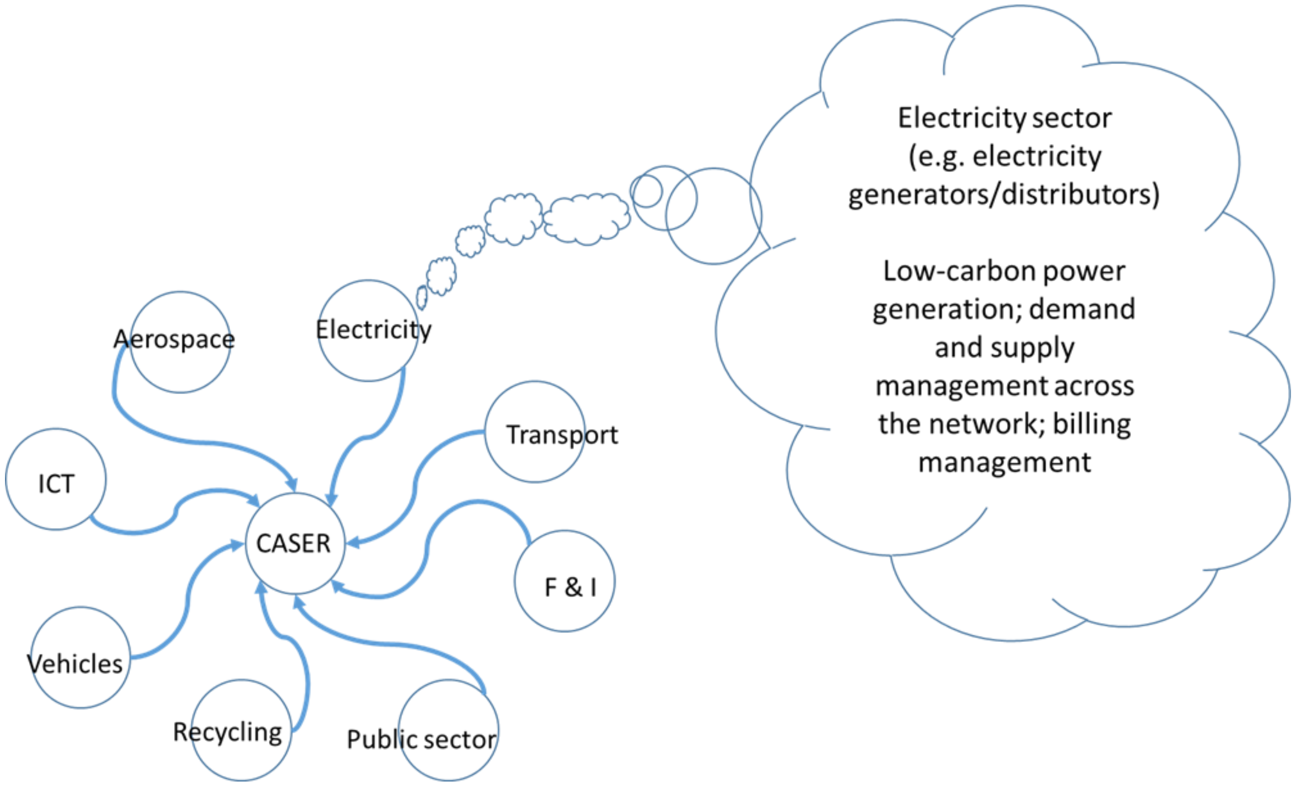

Figure 10: The automobility system (Electricity sector)

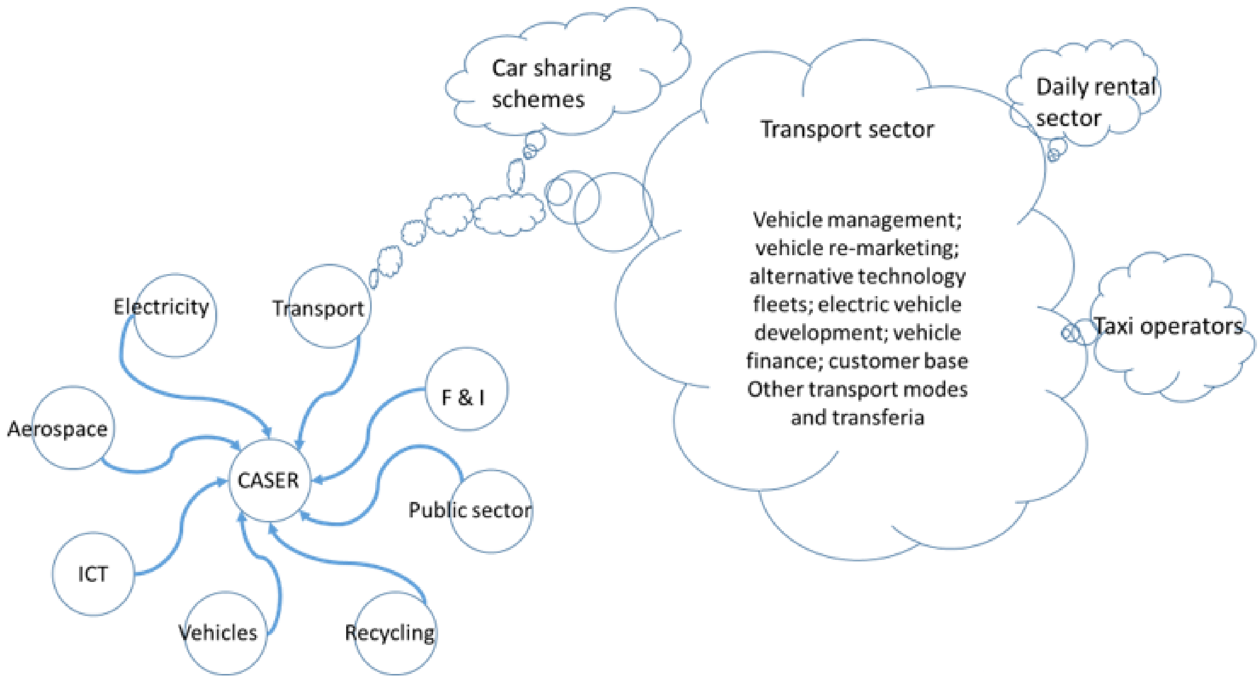

Figure 11: The automobility system (Transport sector)

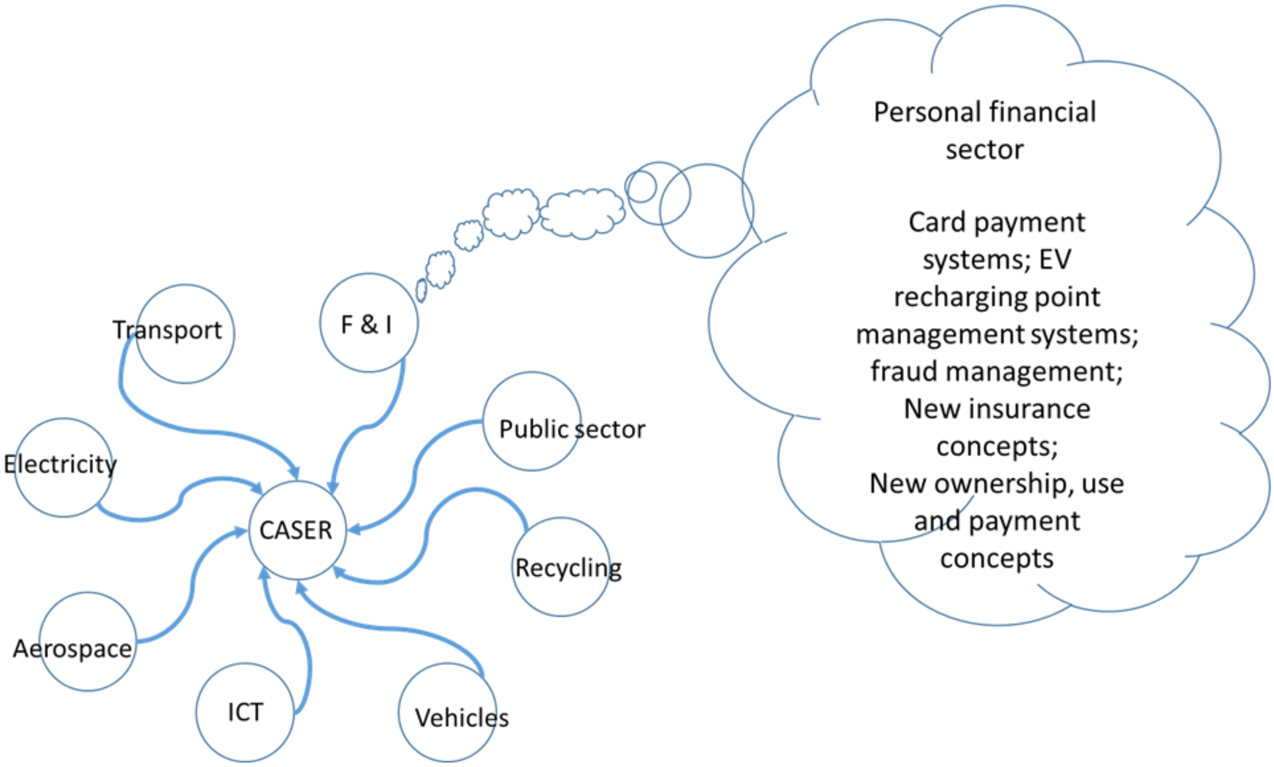

Figure 12: The automobility system (Personal financial sector)

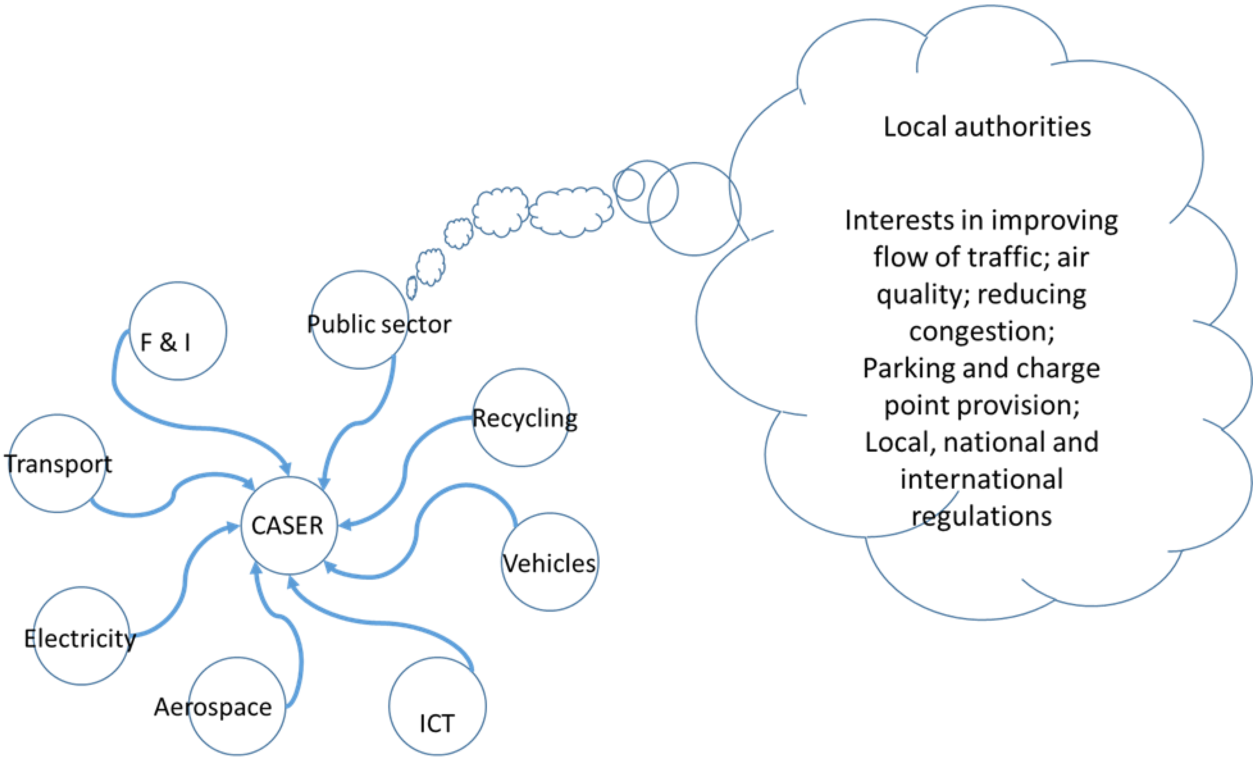

Figure 13: The automobility system (Local authorities)

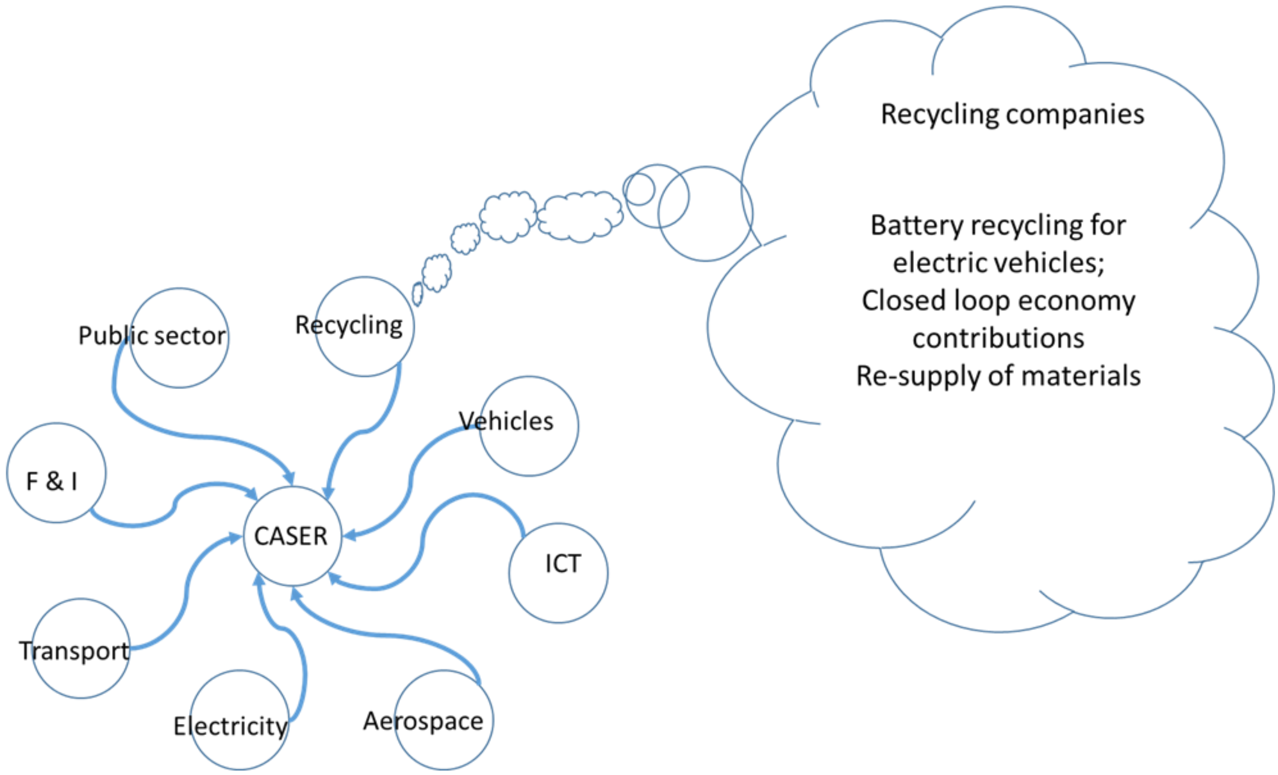

Figure 14: The automobility system (Recycling companies)

In practice, reconciling differences between the automotive industry and potential new participants has proven difficult. An example is the failure of Apple and BMW to find a way to work together (Taylor and Love, 2015). Equally, it is not always easy to account for new entrants. For example, Dyson is a UK manufacturer of domestic appliances (vacuum cleaners in particular), but there has been persistent rumour that the company is interested in developing and producing an EV. In 2018 it was reported that Dyson was recruiting an additional 300 engineers (to the 400 already working on the project) with a view to market entry by 2019 (Beckwith, 2018). The company claimed an investment of £1 billion ($1.3 billion) in the forthcoming EV, along with an equivalent amount in solid state battery technology (Adams, 2017).

New entrants have the possibility of rewriting the rules of competition, in part because they are not encumbered by existing sunk investments and brand heritage. Moreover, business model innovation may be a necessary feature of competitive survival in the face of traditionally powerful incumbents. New entrants can emerge in a variety of forms, from small and entrepreneurial start-ups to the spin-out creations of existing automotive industry companies. A feature of electric vehicle technology is that it can be applied relatively easily in simple vehicle structures that may be economic to produce at low volumes. This is especially so if the 'vehicle' is not a full size (EU M1) car, but something rather less. Indeed, there is some sense in creating regulatory spaces that will allow non-cars to prosper in the future. New entrants can also emerge from large and resource-endowed

companies in other sectors that are seeking new markets. There have been notable failures over recent years including Fiskar, A123 Systems (Batteries), Coda Automotive, Bright Automotive, Aptera Motors, Miles Electric Vehicles, Ecotality (recharging networks), Next Autoworks Co. and of course Better Place (recharging networks). Example new entrants include Tesla, Lynk & Co. and Riversimple.

With the introduction of the Model S in mid-2013, Tesla became synonymous with entrepreneurial success in the nascent electric mobility market with strong product reviews for the car and optimism for the business model underwriting a surging stock market price in the US (Wells and Nieuwenhuis, 2015). This optimism has remained, up to and including production of the Model 3 in 2018, despite the lack of profitability and a repeated tendency not to meet stated production and revenue targets. Tesla claimed several new aspects to the business model adopted, as is shown in Table 3.

Tesla Innovation	Pre-existing example
Ownership of retail outlets	Common and long-established practice in the EU; Adopted by Daewoo as a market entry strategy in the UK in the 1990s. Innovative in the US, but often constrained by State laws disbarring manufacturers from retail activities.
Creation of 'boutique' retail or experience outlets in shopping malls and other mixed retail locations	Attempted by Smart during early phase of marketing. Parallel examples include the Toyota Amlux Centre in Tokyo and the VW Wolfsburg 'Autostadt' brand experience facility. Increasingly common now as 'popup' stores in shopping centres, airports, and even festivals.
Fixed price, 'no haggle' retailing	Adopted by Daewoo as a market entry strategy in the UK in the 1990s. Often the de-facto practice for brands or models in high demand, though not common in mass produced cars.
Provision of free access to unlimited charging via own fast-charger infrastructure (30-minute recharge)	No comparable example, but many instances where new cars have been offered with 12-month supply of petrol, insurance, etc.

Tesla Innovation	Pre-existing example
Battery swap system (on Model S) allows replacement in 90 seconds at US$60-80 per swap.	Initially tried by Better Place (now bankrupt). Only works for Tesla S models despite US$500,000 cost per swap station. Remains an area of interest for Tesla but not a priority
Cars built to order, not sold 'off the lot'	Very common in Europe, particularly for prestige and sports cars for at least a proportion of total output. Tesla has a strong order book and a long waiting list for the Model 3 which allows this strategy to be followed.
Ordering new cars via retail outlet or Internet	Internet retailing is well established, though because of legal constraints orders still need to be routed via dealerships.
High levels of vertical integration (estimated at 70% by value)	Historically common (e.g. Ford; VW); widespread for key technologies and materials e.g. fuel cells; magnesium. Production of battery cells and packs at the Gigafactory helps to guarantee supply, but the battery packs are a unique design with concerns over recyclability.
Introducing new brand, new model and new manufacturing facility simultaneously	An even more ambitious version of this was attempted at launch by Smart with the Hambach plant.

Table 3: A comparison of the business model innovations from Tesla with pre-existing innovations (Source: Adapted from Wells and Nieuwenhuis, 2015)

Lynk & Co. was founded by Geely and Volvo in 2016. Volvo was purchased by Geely in 2010 (see https://www.lynkco.com/). Elements of the business model resemble the offer from Tesla, including haggle-free pricing. The company offers the option of purchasing a car, leasing, sharing one, or subscribing to one. A simple menu of four trim levels is offered. Cars are based on Volvo models (e.g. the Volvo XC40 is the basis of the 02 model). Again, there are manufacturing advantages to this strategy as it reduces complexity. It is the opposite to the traditional approach of the main luxury brands that specialise in the ability to customise cars to suit individual requirements and tastes. Such customisation can be highly profitable.

According to Kirwan (2018) Lynk & Co. will use central city locations in the major EU countries (i.e. London, Paris, Berlin, etc.) but concentrate mostly on popup stores and virtual showrooms. So, there will be no franchised dealers, while the subscription system will include insurance. There will need to a lot of stock because the company claims from order to delivery will only take 24 hours.

The existing Volvo network of franchised dealerships will be used for service and repairs. In the case of Lynk & Co. then there is a hybrid business model that should reduce some fixed costs, but with large elements of the system still unclear. For example, it is not known what happens with vehicles traded-in after first use.

Riversimple is a much more radical proposition in virtually all aspects of product design and business model (Wells, 2016). In the case of Riversimple the production technologies, the product design, and the innovations in business model and governance structure are all integral to the activity of providing zero environmental burden mobility (Bocken et al., 2015). This 'whole system design' is thus key to understanding the potential contribution to degrowth as a 'flourishing' business (Bocken et al., 2013). The over-arching business model is shown in Figure 15.

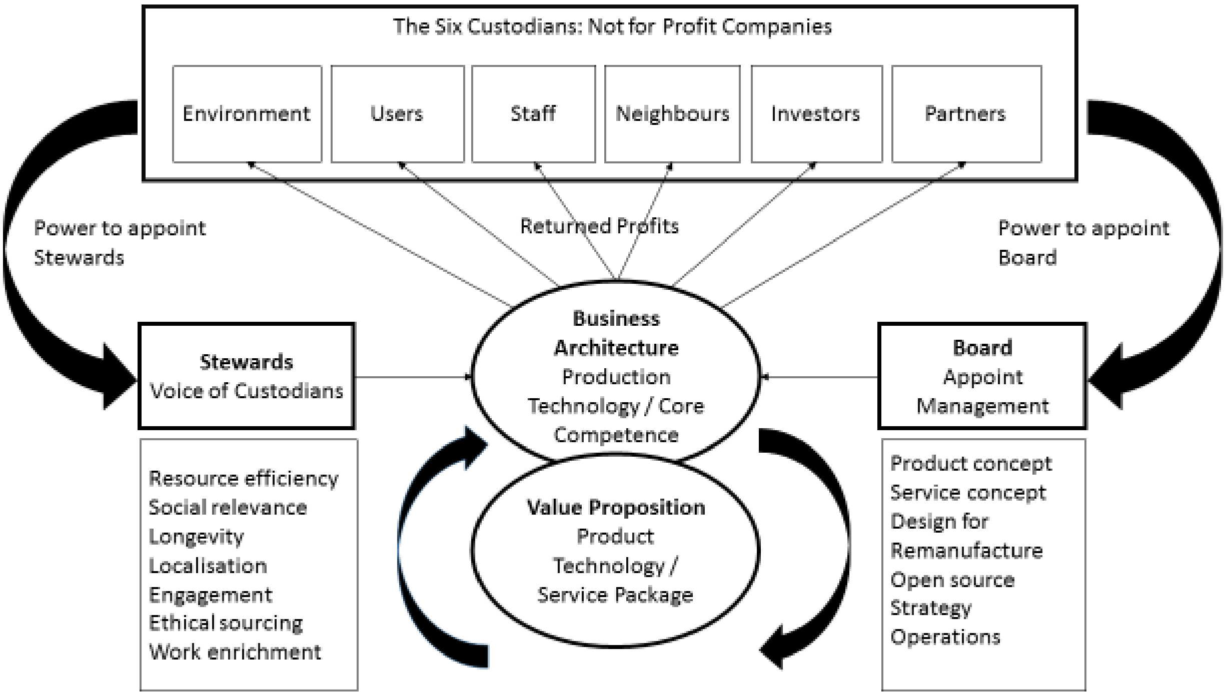

Figure 15: The Riversimple business model (Source: Wells, 2016)

Of relevance to car sharing is the idea that the vehicles are never sold to an end user, individual or corporate. Vehicles are leased on a per-distance basis but are then intended to be recalled to the factory for refurbishment and re-release. While Riversimple is still an embryonic business that has yet to put these and other ideas into practice, there is a resonance with the ideas of the circular economy and shared use.

An example of business model innovation from the mainstream industry is the Renault EZ-GO, an electric, autonomous, shared "robo-vehicle" concept which is both a vehicle and a service that allows people to hail a ride either from a fixed or mobile location. According to the Renault press release:

> *"Ride-hailing and shared mobility services represent an important opportunity for Renault, especially in cities. Many have aging - or very young - populations, and people looking for new mobility solutions.... We've started exploring new mobility services already, and combined with our expertise in individual cars and light commercial vehicles, we believe Groupe Renault will be well-positioned to serve this potential market with electric, connected, autonomous mobility services in both consumer and business-to-business scenarios. EZ-GO is helping us further explore what the future could look like."* (Thierry Bolloré, Chief Operating Officer, Renault).

While such concepts are not concrete forecasts for a future, they do represent a vision and a direction of travel. Typically, concept cars are created and shown for a diverse set of motives. They may be used to suggest future styling trends, or novel technology applications, or innovative design packages, or simply to add 'excitement' to the brand. Concept cars are rarely road-legal or production-ready. For Renault in their press release (Renault, 2018) the EZ-GO concept as a design was clear:

> *"We designed Renault EZ-GO to be an iconic symbol for cities. This electric, autonomous concept explores the positive potential impact of shared mobility for all...Visually appealing and integrated in the urban environment, it offers an unprecedented 360 degree "open window" on the city and a convivial space for people to relax and enjoy the ride."* (Laurens van den Acker, Senior Vice President Corporate Design, Renault)

A crucial unknown for the future is how far the CASE concept or those related to it will result in fundamental changes to the automotive industry business model. In principle, the change could be profound as the industry shifts from a linear, product-centric business model to a circular, service-centric business model. Equally in principle the industry may be able to absorb these concepts without profound change to the linear business model. At the end of September 2018, as was shown in D3.2, the industry has accommodated car sharing within a broad portfolio of routs to market without significant change.

Hence it is useful to consider not just innovation in car sharing business models, but the wider fit of car sharing into automotive industry business models. For the automotive industry there is also the question of how the sector relates to other sectors such as computing, mobile telecoms, energy production and distribution, and other aspects of the economy.

Section 3.2 considers the fit of car sharing into the bigger picture of automotive industry business model innovation. Section 3.3 then places this emergent shift to 'automobility' in the context of intra-sector confluence.

3.3 Cross-sector relationships and emergent automobility

Vehicle manufacturers are engaging in a host of new relationships in a bid to capture a share of the emergent automobility market. These relationships are many and varied. They can include alliances, equity joint ventures, acquisitions, minority shareholdings, and other forms. Participants can include:

- 'Mature' new entrants (i.e. large companies traditionally outside the mainstream automotive industry such as Apple);
- Technology suppliers in e.g. software, mobile telecommunications, electronics;
- Other vehicle manufacturers;
- Traditional automotive industry suppliers that have taken on new technologies (e.g. Continental AG);
- Small-scale start-ups and entrepreneurs.

It is illustrative that in 2017 VW Group announced the Berlin start-up and technology conference "CUBE Tech Fair" from May 10th to 12th. According to a VW Group press release (VW Group, 2017):

> *"We have top know-how within the Volkswagen Group and are expanding it. For this purpose, we are cooperating with first-class technology companies throughout the world as well as with small, highly innovative start-ups. We appreciate start-ups as key providers of impetus and partners give them the boost they need to pursue their ideas successfully. This is a win-win situation." (*Dr. Martin Hofmann, CIO of the Volkswagen Group)

At the end of 2015, VW Group IT established the Ideation Hub, a department whose main task is to bring Volkswagen and young start-ups together. The Ideation Hub identifies ideas in the international start-up scene, approaches the young entrepreneurs and supports them through to the implementation of a pilot project within the Group. The portfolio of pilot projects already completed ranges from 3-D printing applications to mobility services such as the intelligent use of geographic data.

To tease out more detail, Volvo is used as a case study (Wells and Wang, 2017). This vehicle manufacturer is interesting as it illustrates both the unique characteristics of each vehicle manufacturer in terms of context, brand history, available options and so forth, but also some generic outcomes that might apply more broadly. In terms of the generalizable propositions defined, Volvo

does indeed exhibit several QDI relationships that push against the boundaries of the traditional automotive industry sector. Table 4 provides a summary of these relationships for Volvo.

Company	Date	Item
Siemens	31/08/11	Joint development of electrical drive technology, power electronics and charging technology as well as the integration of those systems into Volvo C 30 Electric cars. Models shown in 2014. In 2013 the two companies showed a novel superfast charger. The PHEV XC90 in 2016 used Siemens electric motors.
Uber	18/08/16	Combined US$300m investment in autonomous technologies.
Autoliv	06/09/16	Set up a joint venture company with Autoliv to accelerate the development of advanced driver assistance technologies and autonomous car technologies.
LG Electronics	04/11/16	Proposal (not verified) to enter into wide-ranging agreement for the co-development of components and systems for electric cars and autonomous cars.
Nvidia; Autoliv	27/06/17	Plan to develop software systems for self-driving cars; to develop systems that use artificial intelligence to recognize objects around vehicles, anticipate threats and navigate safely.

Table 4: Volvo and quasi-diagonal integration (Sources: CB Insights, 2017; Lee and Park, 2018; Johansson and Deniz, 2014)

An important starting point in terms of autonomous car technology for Volvo has been the long-established relationship with Tier 1 supplier Autoliv. This relationship helped form the basis of the joint venture business announced in September 2016 of which the CEO Hakan Samuelsson said:

> *"By combining our know-how and resources, we will create a world leader in AD software development. This means we can introduce this exciting technology to our customers faster."* (Cited in Volvo, 2016).

Volvo Cars became part of the Geely Group (China) in 2010, having been sold by Ford. The link with Nvidia is key to the effort to develop autonomous cars. Nvidia, also has partnerships with Toyota, Audi and Mercedes. Meanwhile, in a separate cluster, BMW has relationships with Intel (US) and Mobileye (Israel, with expertise in vision systems and mapping), with a similar aim of developing autonomous cars. Moreover, Delphi and Continental, both traditional automotive suppliers, have since joined the BMW cluster. Interestingly, although Daimler (owner of the Mercedes brand) has links with Nvidia, it also has fostered a relationship with Robert Bosch with a focus on autonomous cars. To further complicate the picture, Bosch itself is developing capabilities in 'new' markets such as short-term motorcycle rental. According to Board Member Rolf Bulander:

> *"While there are market segments where we are clearly a supplier, there are markets which are not yet developed where new players are emerging, this includes us." (*Cited in Rehle, 2017).

Furthermore, in 2017 Ford, in an almost-traditional acquisition move, has planned to invest 1 billion$ over 5 years into Argo AI, a start-up company in the US specializing in artificial intelligence, a technology which is widely held to be vital if cars are to reach Level 5 autonomy (Marshall, 2017). It is notable that Jaguar Land Rover has in 2017 announced the intention to recruit an additional 5,000 engineering employees, of which at least 1,000 would be in software and electronics (Allen, 2017). In this it is evident that there are multiple strategic options available to the automotive industry, but no uniformity of solutions.

In other words, the case of Volvo is illustrative of a wider trend: many of the companies that comprise the 'borderless' automobility industry are themselves becoming less distinct but such a 'rule' is not absolute and need not apply to all aspects of the emergent automobility industry. Therefore, the Volvo case is illustrative of a form of semi-exclusive micro-network of QDI and other relationships that in effect form a new cluster of competences in which Volvo seeks to retain a central role.

The assumption in the academic literature is that firms engaged in integrating across knowledge fields seek to maintain their distinctiveness and independence while simultaneously gaining knowledge transfer (Schulze, et al., 2014). However, in the highly contested and turbulent context outlined in this report it is by no means certain that such mutually beneficial outcomes will obtain. To underline the concern with commodification, it is also clear that for Samuelsson at Volvo Cars the potential of autonomous car technologies is clear:

> *"If you're only providing transportation from A to B, you're heading into trouble…You still need to have a car that is not just fulfilling the transportation need, but also giving our customers an emotional value, a premium car."* (Cited in Naughton, 2016)

In this quote Volvo is pursuing a distinct interpretation, or framing, of how the company seeks to understand and then capitalise on the integration of autonomous technologies in a particular way. Similarly, in the work with Siemens on electric powertrain, Volvo has sought bespoke rather than off-the-shelf technology solutions in items such as electric motors with the view that such solutions will assist in retaining the brand distinctiveness of the cars and hence the ability to recover costs from the market. The strategy is further underlined by the decision to develop the 'Polestar' branding for the luxury segments to compete with cars from companies such as Tesla and BMW.

Another illustrative case is Mobileye, an Israel-based mapping navigation and driving assistant company, owned by Intel since March 2017. Table 5 illustrates detailed affiliation events between Mobileye and other businesses.

Company	Date	Item
Valeo	11/03/15	Signed an agreement to co-develop automated driving productions, in which Valeo design and produce cameras and Mobileye is responsible for sensors and vision algorithms via its EyeQ system.
GM and Volkswagen	11/01/16	Partnership with Mobileye to refine digital map system more accurately.
BMW and Intel	30/06/16	Pooling all technologies and vehicle integration skills to create a fully automated vehicle on the BMW iNext.
Delphi	23/08/16	Jointly to foster an autonomous and connected driving system and reach level 4 or even 5 from 2019 onwards.
HERE	29/12/16	HERE Open Location Platform would have a strategic partnership with Mobileye Readlook technology then integrate to become a high performance digital mapping system
Intel	14/03/17	Acquired by Intel $14.7 billion.
Nissan	25/04/17	Forge an agreement in next generation of driving mapping auxiliary systems for safety and autonomous driving vehicles.
Continental AG	20/06/17	Joined the alliance of BMW, Intel and Mobileye
VW	20/02/17	Volkswagen and Mobileye created new ‘super navigation data’ for autonomous driving

Table 5: Mobileye and quasi-diagonal integration (Sources: Wernle, 2015; Beene, 2016; Scheer, 2017; Irwin, 2016; VW Group, 2017b

Mobileye has a short history specialising in navigation, mapping and driving assistant systems. The EyeQ software system is the core product for Mobileye. It has been used by around 30 vehicle manufacturers around the world, and was upgraded to the fifth generation recently. The newest generation helps car sensors in detecting movement and navigation as the basis of a fully autonomous driving system. Mobileye worked with traditional Tier 1 automotive supplier, Valeo, to help align the system to automotive standards of cost and reliability. Valeo produces hardware such as camera systems, lasers as well as sensor scanning ‘hardware’, while Mobileye’s data manipulation and algorithms provide the software (Wernle, 2015). Thereafter, Mobileye and Delphi developed a Central Sensing Localization and Planning (CSLP) Platform that integrates navigation and autonomous driving. In this case, Mobileye contributed EyeQ 4/5 System on a Chip (SOC), and its Road Experience Management (REMTM) mapping system and learning system. Delphi contributed the core hardware and the Multi-Domain Controller, radar and Lidar sensors, and automatic driving algorithms (Irwin, 2016).

In 2017, Here, which took more than a 70 percent share in the navigation market, announced it would have a collaboration with Mobileye in the digital mapping arena. Here is also furnishing software to technology companies such as Microsoft and Samsung, and also automakers like Hyundai, Toyota and Honda (Burke, 2016). BMW and Intel formed an alliance and, after the joint development of technologies, in 2017 they announced the intention to trial 40 autonomous test vehicles in public.

Apart from founding alliances, vehicle manufacturers also have initiated independent cooperation with Mobileye. For example, Volkswagen Group and GM with Mobileye have created digital mapping systems, while Volkswagen Group acting alone has signed an agreement with Mobileye for the operation of its navigation system.

CONCLUSION

This report has been concerned with the wider and strategic impact of car sharing on the automotive industry. It is concluded that any substantial impact from car sharing will only emerge when and if the industry simultaneously adopts other key innovations around connectivity, autonomy, and electrification as part of a radical re-design of business models to suit circular economy concepts. While such an end-state can be envisaged, and is already evident in embryonic enterprises such as Riversimple, the process of transition from the current situation to some idealised future is the most problematic element.

At present, vehicles are not being designed explicitly for car sharing. The only exceptions are innovative entrepreneurial new entrants showing radical new mobility concepts, but with no real prospect of market entry at present. Some of the existing component industry may be tempted further into the market, as has happened in the case of electric bicycles where component suppliers have indeed gone on to manufacture and sell entire electric bicycles. Entry by components producers is less likely in the case of cars, because the barriers to entry are that much higher.

Previous efforts at designing vehicles for car sharing, and pulling in new suppliers to the industry, have not been successful. The MIT / Hiriko vehicle captured significant public attention and, ultimately, public funding. However, the scheme collapsed amid financial chaos. Autolib, with a much higher profile and even greater financial support, also collapsed. Such events matter. It is likely that public authorities will be more cautious in the future.

There are positive signs, however, regarding the innovations around the CASE concept in that much of the ongoing developments are mutually supportive and beneficial. That is, emergent practices regarding electrification, autonomy and communications are overall likely to be supportive of car sharing rather than inimical.

In terms **connectivity**, there are potential benefits because:

- ★ It helps users book, locate and pay for the cars in a seamless and rapid manner;
- ★ It helps users new to a location with navigation;
- ★ It helps operators track cars and monitor their condition;
- ★ It can be linked to insurance to obtain the best possible rates.

Connectivity in the vehicle and for users is vital for app-enabled software that allows subscribers to access and pay for vehicles. Connectivity is also a valuable element in allowing operators to manage the entire fleet. Further enhancements are likely to emerge, for example to enable more sophisticated pricing structures that more accurately reflect the time and location of

This project has received funding from the Horizon 2020 programme under the grant agreement n°769513

usage, the routes used, etc. Such precision would enable, for example, peak travel to be charged at a higher rate; or more 'risky' routes and locations to be premium-priced.

In terms of **autonomy**, there are potential benefits because:

- It reduces the likelihood and severity of crashes, so protecting users and lowering costs.
- Reduced crash damage also reduces maintenance costs for operators, and reduces unanticipated vehicle downtime.
- It reduces the chances of driving rule violations, and so reduces the management costs of processing legal claims.
- It is especially useful for drivers new to a location or driving situation.
- It expands the potential range of vehicle users and occupants in the case of fully autonomous vehicles.
- It may include some useful 'surprise and delight' features such as self-parking.

One ongoing concern for Autolib was the deterioration in the physical condition of the vehicles. At least in terms of external damage, the deployment of some of the technologies involved in autonomous driving might reduce costs and vehicle downtime. As noted above, higher levels of autonomy could also reduce costs for users by avoiding impacts and associated damage, with additional benefits for operators in reduced claims management.

Fully autonomous are still distant from widespread 'real world' usage. As some form of progressive deployment emerges, there may even be a market expansion effect because previously excluded users might be able to access vehicles via shared schemes.

In terms of the wider CASE concept, **EVs are potentially good for car sharing** because:

- They are generally easier to drive than a traditional manual gearchange car and hence appeal to a wider range of potential users.
- The powertrain has fewer moving parts making it inherently more reliable, and hence there is less downtime in terms of capacity utilisation.
- It enables car sharing users to enter into zero / low emissions zones, thereby giving users greater freedom of choice than traditional ICE cars.
- They fit against the wider social ethos of some car sharing schemes in that they contribute to good citizenship by being quieter and non-polluting at source.

The prevalence of EVs on shared fleets is a phenomenon that has already been noted in this report. In some respects, it is a surprising outcome. EVs are constrained by both range and the need to charge at specific places that are suitably equipped. Some of the problems experienced by Autolib can be attributed to the additional challenges of managing an EV fleet for sharing.

For car sharing schemes there are some benefits however. Perhaps the most important is the 'fit' with social aspirations to reduce the negative externalities associated with car ownership and use. Shared EVs promise fewer cars, but also quieter and non-polluting cars. For urban transport planners and the communities that they serve, this is potentially an attractive package of features.

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