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Feasibility study and prototyping of a blockchain-based transport service pricing and allocation platform

Final Report

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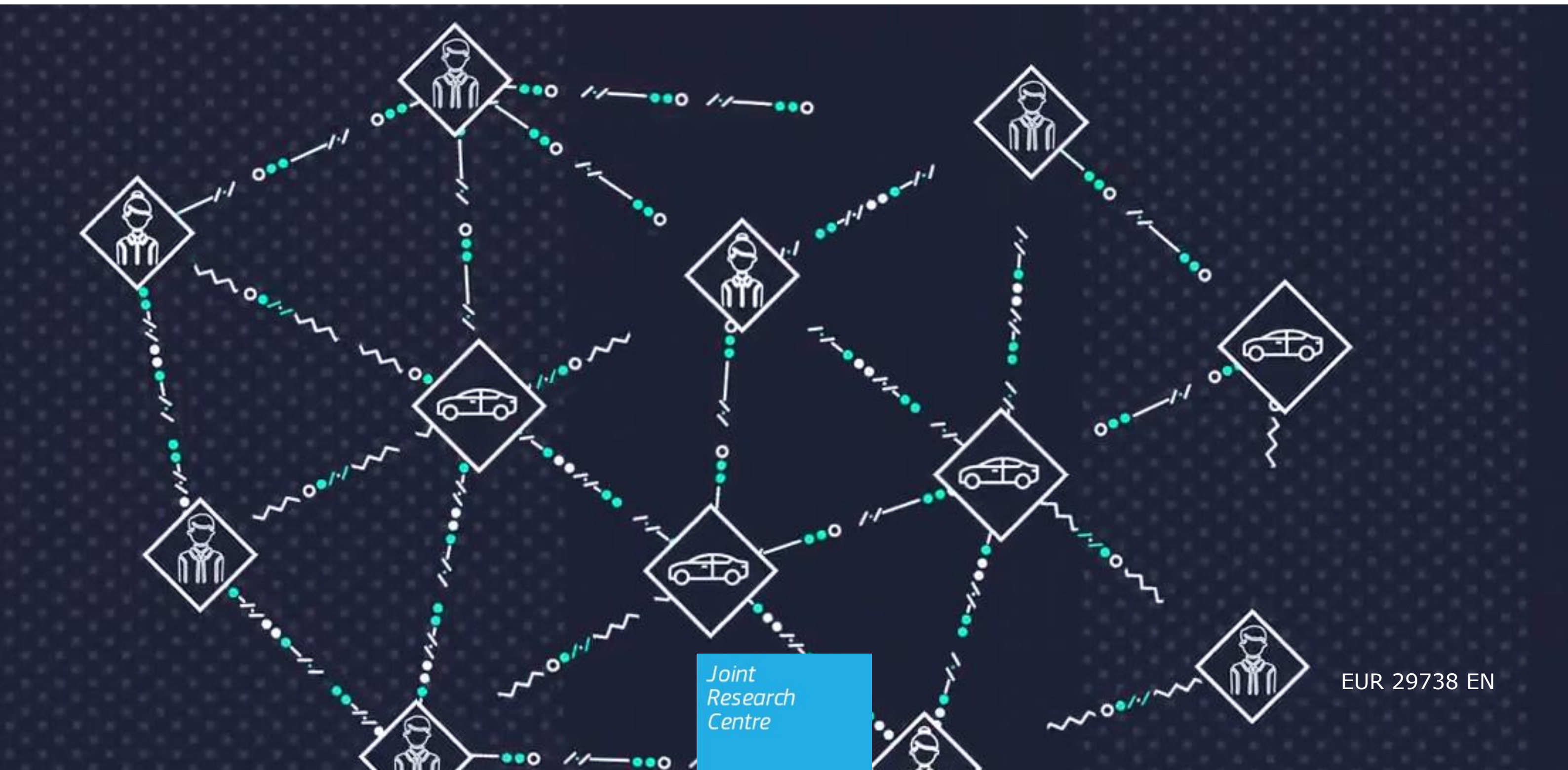

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Abstract

This report summarises the activity and findings of the JRC Proof of Concept Project Ridechain. The project investigated the applicability and market potential of blockchain technology for asset sharing in the road transport sector.

The project comprised two principal activities. The first activity was market research and analysis to support the development of a new service concept and business model for blockchain-powered shared mobility. Specifically, the research resulted in the definition of a novel technology platform that leverages blockchain, cloud services, and in-car technology to enhance trust, streamline coordination and improve information exchange in P2P car sharing ecosystems. The second activity was technology prototyping to demonstrate the technical feasibility of the novel service concept using state of the art blockchain and IoT frameworks.

These two activities provided answers to two respective research questions. First, what would be a high-value transport sector market to which a blockchain-powered technology product could offer a high-value solution? Second, how could this technology product be realised?

The report starts with an introduction to distributed ledger technologies and applications of blockchain in transport and presents a brief overview of innovative business models in goods and passenger transport. The report continues with an outline of the agile product discovery methodology followed throughout the project, which emphasises experiment-driven validation in order to minimise risks relating to customer value, technical feasibility and financial viability.

Next, the report presents the market analysis and research results derived through the application of this methodology. It discusses different transport service markets and their respective growth characteristics and examines a selection of the most promising service models from the perspective of the value that blockchain technology has to offer. Decentralised car sharing is singled out as a high-value market of high growth potential in the wider sector of shared mobility. The report continues with competition analysis relevant to the identified market and proceeds with analysis of alternative business models for consumer to consumer and business to business car sharing captured with a Business Model Canvas. The assumptions underlying the business value ideation are identified and characterised with respect to impact and uncertainty, leading to the design of a series of market validation experiments. These experiments are presented along with the data obtained from 11 semi-structured qualitative interviews and answers collected from 254 online survey participants.

The report comes to a close with an overview of the conceptual architecture of the developed service concept and a description of the steps taken to demonstrate its technical feasibility.

Executive summary

This report summarises the activity and findings of the JRC Proof of Concept Project Ridechain. The project investigated the applicability and market potential of Blockchain (BC) technology for asset sharing in the road transport sector.

Concepts investigated include the utilisation of existing capacity of vehicles for the transportation of passengers and goods, possible improvements in the sustainability of the sector, and the dynamics of same day delivery and shared mobility markets. As required by the JRC's Proof of Concept project guidelines the activity had a strong business orientation. Various alternative business models have been formulated and assessed, and the most interesting ones, in terms of market potential, were thoroughly studied with regards to the likelihood of actually reaching the European market. In parallel, the team has worked on a first demonstrator where the interactions of different users are stored on a blockchain, using predefined smart contracts, keeping track of the exchange activities between the users and eventually enabling a form of either direct (monetisation) or indirect (tokens or miles aggregation) valuation of the service. For doing so the project team relied on existing tools available to the JRC in order to create a blockchain-based framework where the users can request or offer transport services.

These two parallel research activities provided answers to two respective research questions. First, what would be a high-value transport sector market to which a blockchain-powered technology product could offer a high-value solution? Second, how could this innovative product be realised with state-of-the-art technology?

Research background

Passenger transport and goods transport are two sectors which undergo rapid changes. The sharing economy is transforming markets around the world and passenger transport markets are no exception. We are witnessing a shift in consumer mindset, transitioning from prioritizing vehicle ownership to prioritizing vehicle usage. In a 2016 survey of 16,469 consumers across 16 countries, which was carried out by IBM, 40% of respondents were very interested in subscription pricing, while another 25% of respondents were very interested in fractional ownership of vehicles. We can distinguish between three alternative models of shared mobility, Ride-hailing, Ride-sharing (car-pooling), Car sharing.

Transport of goods is also an ecosystem in transition. In a 2017 study, Deloitte predicts a decline in the sales of heavy and medium commercial vehicles through to 2026, but analysts also expect this shrinking fleet will move 27% more goods in 2027 than it did in 2016. Demand for goods shipping is growing – fuelled primarily by a growing volume of online sales. New technologies and market dynamics are reshaping every stage of a product's journey – especially the last mile. The convenience features that customers prioritise in relation to last mile delivery are: alternative pickup and delivery options (e.g., parcel locker-boxes), flexible delivery timing (i.e. scheduled/deferred delivery), delivery speed (i.e. instant, same-day, next-day delivery), with the latter being probably the most interesting in terms of expected market growth.

Blockchain technology is still striving to find its place in the transport sector and the uptake of Blockchain based implementation in the market segments listed previously remains marginal. Many of the current market activities will, most probably, fail to materialise, though earning their contributors valuable insights into the application of blockchain, preparing them for future adoption. Research efforts are still important if inherent technology shortcomings, such as scaling and interoperability among different frameworks, are to be solved and subsequently support real world transport scenarios on a large scale. Nevertheless, the future opportunities that can spawn from broader implementation of Blockchain technology in the transport sector are widely recognised.

Refining the scope of the research

Transport of goods and transport of people are the two sectors of potential interest foreseen by the original Ridechain project proposal. Both sectors present significant opportunities for growth and for new innovative business models. The two areas within those sectors which are most vibrant in terms of innovation and investment activity are same-day delivery and shared mobility, respectively.

Following an iterative process of market research and analysis the research team gradually narrowed down the focus of the project to a specific transport sector, a specific service model within that sector and a specific beachhead market to validate customer demand and perception of value.

Which transport sector?	
Options	Goods transport vs passenger transport
Decision criteria	Sector growth, ease of access, team advantage
Verdict	The shared mobility sector affects all commuters on a daily basis. It showcases a higher annual growth rate and new innovative models are currently being tested and offered in the market with significant initial traction. Traditional industrial stakeholders like Daimler and BMW are already successfully operating shared mobility services and plans of consolidation indicate strong drivers for growth. Furthermore, shared mobility falls directly within the available expertise and market access potential of the research team.
Which mobility model?	
Options	Ride hailing vs ride sharing vs car sharing
Decision criteria	Value of blockchain, i.e. importance of information sharing, process coordination and trust to each model.
Verdict	Considering the fact that the transfer of assets among disparate partners is prominent in the car sharing model, enhanced trust and coordination along with reliable information exchange is paramount to drive growth in this market segment and facilitate diversified business models.
Which type of car sharing model?	
Options	Centralised vs decentralised car sharing
Decision criteria	Which market would be more impacted by the use of BC technology?
Verdict	BC technology was purposefully designed to offer unique benefits to decentralised networks comprising disparate entities. As such the technology is directly suited to peer-to-peer car sharing models, where trust, coordination and reliable information stand to greatly affect solution uptake.

Which beachhead market?	
Options	Consumer to Consumer (C2C) or Business to Business (B2B) decentralised car sharing networks
Decision criteria	Which market is most compelling and would potentially uptake a proposed solution?
Verdict	Small to medium sized managed fleet owners, such as car rental companies, practise subletting as part of their daily processes in order to handle fleet flexibility over high and low seasons and increase profitability. Their market is mature but not supported by any purpose-built ICT solutions to facilitate exchange among professional peers. Subletting is based predominantly on trusted private networks, which restricts their reach and eventually their choices and on-demand responsiveness. The proposed market showcases compelling characteristics as it is valuated at €58.26b in 2016 with an estimated CAGR of 13.5%. Closer to home the European car rental SMEs represent 35% of the entire EU car rental market at an estimated €4.2b.

Methodology

To be able to frame an innovative business model on the foundation that a blockchain-powered technology product offers a high-value solution to a high-value transport sector market, and be able to proceed with implementing a minimum viable product to validate that business model, ideas have to be placed in front of real users and customers early and often.

There is a clear need for a structured product discovery methodology that can provide all the supporting information and indicators of potential success, to drive product development and initial market entry. One of the most prominent among the modern product discovery methodologies used by startups around the world is the Lean Startup methodology first proposed by Eric Ries, which outlines hypothesis-driven experimentation, iterative progress and validated learning.

The research team followed an agile product discovery process based on this methodology in order to minimise the different types of risk inherent in every product innovation effort:

- Customer Value Risk – Will the targeted market recognise high value potential and choose to buy the proposed product?
- Technical Feasibility Risk – Does the team have the skills and resources to build it?
- Financial Viability Risk – Will the proposed product and revenue model prove to be financially viable for a business?

Results obtained

The value proposition for the selected beachhead market, i.e. for business-to-business car sharing networks / owners of small managed fleets, should revolve around the following key axes:

- *Fleet flexibility*: via the proposed solution, car rental professionals could be able to expand their fleet, on-demand;
- *Low CAPEX*: car rental companies could bring the size of their owned fleet to an absolute minimum, decreasing capital expenditure requirements;

- *Network expansion*: each individual professional could have access to an expanded network of other affiliate trusted professionals and businesses;
- *Efficiency*: the process of looking for cars' availability, making arrangements, and settling contracts and payments, should become streamlined and automated.

Building on these value characteristics, the assumptions tested over the course of the project were based on three main business model variations:

- **B2B offering:** targeting only P2P car sharing activities among professionals
- **B2B+ offering:** P2P car sharing activities among professionals, plus the options for individuals to offer their cars to this network under management by car rental professionals
- **P2P car sharing marketplace:** a P2P car sharing marketplace which professionals and private car owners would use as a platform for P2P car sharing

Alternative approaches have been adopted to select the various assumptions. Each individual assumption has been tested with various "experiments", while results of each experiment have been compared with each other to identify inconsistencies and/or cross-validate the respective assumption.

The B2B assumptions validation experiment was elaborated in a questionnaire to support one-on-one semi-structured qualitative interviews with car rental owners in Greece, supplemented by a cold-call campaign and an email campaign. The overall learnings from the interviews conducted showed that an estimated 20% of revenues is lost due lack of vehicle availability, approximately 30% of revenue is attributed to subrentals (demand or supply), short term rental are more financially attractive than long term rentals, fleet elasticity is highly seasonal and for small car rental companies the fleet size can rise between 40% to 300% percent (depending on size of managed fleet).

- **More than 80% of car companies practice car sharing**, in one way or another (>50% goal)
- **The financial impact is** highly depended on the size of the managed fleet but it seems that **10-15% on average** is an educated estimate (>10% goal)
- Streamlining vehicle supply and demand could lead to an increase of up to 20-40% in revenues as estimated by interviewees (>30% goal)
- **More than 80% of car rental owners would be willing to extend their network** (>30% goal)
- **More than 80% of car rental owners would be willing to adopt a software solution** to extend their network (>20% goal)

A total of 260 calls were conducted using publicly available business contact details from Greek and Italian car rental companies. Following the cold calling process an email campaign was sent out to the emails gathered. To facilitate the process two marketing landing pages were developed (Annex II).

Overall a 2.46% of the recipients submitted the partnership form at this idea stage signifying an early adopters audience in the sector willing to investigate new and innovative solutions. Considering that this is 10% of the recipients who ended up clicking the call to action, the proposed solution seemed to attract considerable and genuine interest by the relevant stakeholders.

To validate the B2C business assumptions a different experiment an on-line survey was designed. This resulted in collecting answers from 254 participants mainly originating from Greece and Italy with a wide age distribution. Out of them, 29.1% would be willing to rent out their car at €36, a price competitive to alternative options such as car rentals. The data indicate that participants belonging to the 18-25 age group constitute the most engaged potion of the public with 38.3%, although they own less cars on average and their perception of cost of ownership is lower than other groups. The prevalent themes of concern were:

- The extent to which insurance coverage would be sufficient for the process of participating in peer-to-peer car sharing
- The prior knowledge (evaluation) of a renter's driving behavior
- The extent to which the process of participating in such a service is automated

In parallel to the feedback received and the conclusions extracted from the market research, an architecture for a platform to support peer to peer car sharing at B2C and B2B levels was designed. Also, substantial effort was placed in the development of a functional prototype. The small-scale demonstrator which was developed consists of 3 components.

1. The smart contract that acts as the escrow between the 2 parties
2. The car probe that currently is used to upload the car coordinates to the blockchain at set intervals.
3. The GUI that is used for all interactions with the contract

The system was presented at the JRC between the 26th and the 28th of November 2018. After configuring the system and setting up a private Ethereum blockchain network, we successfully simulated a ride being hailed (3 of us, 1 acting as the passenger and driver and 2 acting as the car). The main problems encountered during this demonstration were connectivity issues, due to the very restrictive wireless network of JRC. The demonstration proved that a blockchain ride sharing/hailing system is viable and the inherent delay in the network due to transaction verification does not make it unworkable.

Following the extended market analysis and assumption validation process the research team initiated some basic market validation activities. To this end a start-up company was envisaged as a potential spin-off of the Joint Research Centre, Directorate C - Energy, Transport and Climate - Sustainable Transport Unit (JRC.C.4), called **Innomovo**.

The effort included the following four parts:

- A website descriptive of a technology provider in the field of peer-to-peer car sharing space (www.innomovo.com)
- An explainer video included in the website
- A pitch deck to support the Innomovo positioning
- A financial analysis of a SaaS business model, fitting a technology solution provider, such as Innomovo

To further enhance the project's outcomes and in direct correlation with the envisaged architecture a search is on-going in the field of in-car technologies that support blockchain application scenarios. The preliminary research results revealed several technology patents that identify the need for in-car technology able to convey key information about a vehicle's state but also to allow a vehicle to take part as a unique entity in the future mobility landscape, where connected and autonomous cars will be able to interact with drivers, services and infrastructures.

1. Introduction

This report summarises the activity that took place in the framework of the Proof of Concept Project "Ridechain" (henceforward PoC) funded by the European Commission's (EC) Joint Research Centre (JRC). The project investigated the applicability, and market potential of Blockchain (BC) technology for assets sharing in the road transport sector. Concepts investigated included the utilisation of existing capacity of vehicles for the transportation of passengers and goods, possible improvements in the sustainability of the sector, and the dynamics of same day deliver and shared mobility markets. As mentioned in the original scoping paper, the project aimed to investigate the plausibility and the market worthiness of a decentralised, transparent and secure transport-service allocation platform. As required by the JRC's Proof of Concept project guidelines the activity had a strong business orientation. Various alternative business models have been formulated and assessed, and the most interesting ones, in terms of market potential, were thoroughly investigated with regards to their likelihood of actually reaching the European market. In parallel, the team has worked on a first demonstrator where the interactions of different users are stored on a blockchain, using predefined smart contracts, keeping track of the exchange activities between the users and eventually enabling a form of either direct (monetisation) or indirect (tokens or miles aggregation) valuation of the service. For doing so the project team relied on existing tools available to the JRC in order to create a blockchain-based framework where the users can request or offer transport services.

In order to review the business potential behind the originally proposed ideas the project activity was divided in three parts:

1. A market analysis covering the most promising market segments for applying the proposed BC based solution, along with their key characteristics, i.e. size, growth, key players involved and others to be defined in the course of the project. The research focused on competition analysis and provided a detailed overview of the key indicators for analysing available competitive solutions.
2. A review the respective application adequacy corresponding to the chosen business model that lead to the design of a first top level architecture based on the Ethereum BC framework.
3. After the main business case was identified and selected the project team further studied the most appropriate business model using a first round of semi structured qualitative survey results. Following, a first iteration of a Minimum Viable Product (MVP) proposal based on business model aspects and first round of semi structured qualitative survey were formulated.

In parallel and due to the limited time available for designing a fully functional demonstrator that would capture the characteristics of the chosen business model and fully reflect the final business proposition, it was decided that in the interest of the project a first pilot implementation would be created according to the original scoping of the project proposal. Hence the demonstrator focused on ride-sharing and ride-hailing services between individual drivers/users. This activity resulted in the development of a raspberry-pi (RPI) based vehicle communications and tracking system that was linked to JRC's GreenDriving tool in order to make use of existing cost and fuel consumption estimation tools. The concept platform proposed allows for data communication between vehicle and the Ethereum BC network and could be further developed to a full scale car-pooling or car sharing application.

The project started in mid-February 2018 and was concluded in March 2019. The project team comprised of JRC staff and external blockchain and business experts. The following chapters detail the work done.

The report is structured as follows. Chapter 2 summarises the current state of blockchain technologies, their different flavours and characteristics, whilst attempting to offer and overview of the interest and focus of the transport sector in its use, addressing transport of people as well as transport of goods.

Chapter 3 outlines the product discovery methodology followed through the project, in an attempt to minimise risks of customer value, technical feasibility and financial viability. The process is largely based on the Lean Startup Methodology proposed by Eric Ries in 2008.

Chapter 4 introduces the product discovery methodology aiming at framing the transport sector and identifying the market that would benefit the most out of the project's outcomes. It outlines a comparative evaluation between the transport of people and transport of goods markets, leading to an opportunity assessment that considers the project's directive of using blockchain technology as a key element of the value proposition. Subsequently, it addresses the competition in the chosen niche, elaborates a business model, identifies key assumptions and presents the validation experiments conducted. The chapter culminates with a presentation of the experiments' results and a proposed conceptual architecture and market offering.

Chapter 5 showcases the demonstrator conducted as part of validating potential and eliminating the underlying feasibility risk, indicative of the research team's capacity for realising the proposed solution. The demonstrator included software and hardware elements under a limited lab and field level pilot deployment.

Chapter 6 closes the document with an overall summary of project outcomes, whist attempts to identify future steps and suggest follow-up activities.

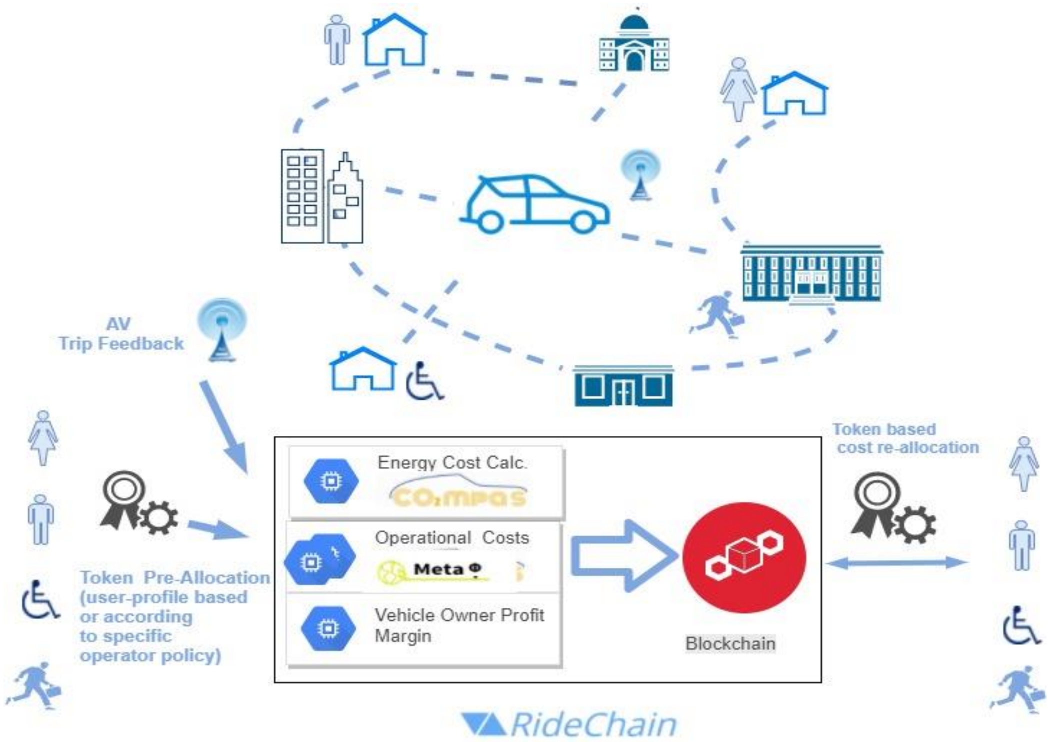

Figure 1 Original project concept

2. Background

2.1 Blockchain technologies

2.1.1 Blockchain in a nutshell

Blockchain was first coined in 2008, by a person (or persons) under the alias Satoshi Nakamoto[1] as a basis of a "peer-to-peer electronic cash system" now known as Bitcoin[2]. At its core a blockchain is a distributed ledger, a chain of custody based on sequential blocks linked with cryptography. It is "*an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way*"[3]. The cryptography used has high Byzantine fault tolerance[4] and thus renders the ledger secure-by-design. It exhibits immutability to change or modification making it a prime candidate for log-oriented architectures. A blockchain is realised by a distributed peer-to-peer architecture of mining nodes, contributing via a common consensus algorithm to the validity of transactions taking place, hence solving the aforementioned byzantine fault tolerance problem, substantiating the highest security to date.

Since the inception of Satoshi Nakamoto several other frameworks were proposed with considerable success. The Ethereum project[5], a spin out project of the Ethereum Foundation led by Vitalik Buterin is one of the most prominent open architectural frameworks partly because it is open and it supports smart contracts.

> "*A smart contract is a computer protocol intended to digitally facilitate, verify, or enforce the negotiation or performance of a contract. Smart contracts allow the performance of credible transactions without third parties. These transactions are trackable and irreversible*"[6]

Smart contracts are rule-based software programs that lie in the blockchain network and can execute transactions between disparate parties without the need of intermediaries. This inherent characteristic has led to a multitude of applications where decentralised architectures including transactional processes are considered an asset.

Similar characteristics are exhibited by other blockchain frameworks, like those hosted by the Hyperledger organisation[7], a project of the Linux Foundation, namely Hyperledger Fabric, proposed by Digital Asset and IBM and Hyperledger Sawtooth proposed by Intel. These distributed ledger technologies were built with enterprise level performance in mind thus differentiating from open blockchains with functionalities such as roles and stratification of access to the ledger itself.

A thorough comparison of open blockchains and distributed ledger technologies was conducted by Dinh, T. T. A. et al.[8] in 2017 indicating the large number of frameworks

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[1] Nakamoto, S. (2009). Bitcoin: A peer-to-peer electronic cash system. Cryptography Mailing list at https://metzdowd.com

[2] https://bitcoin.org/en/

[3] Iansiti, M., & Lakhani, K. R. (2017). The truth about blockchain. Harvard Business Review, 95(1), 118-127

[4] https://en.wikipedia.org/wiki/Byzantine_fault_tolerance

[5] https://www.ethereum.org/

[6] https://en.wikipedia.org/wiki/Smart_contract

[7] https://www.hyperledger.org/

[8] Dinh, T. T. A., Wang, J., Chen, G., Liu, R., Ooi, B. C., & Tan, K. L. (2017). Blockbench: A framework for analyzing private blockchains. Proceedings of the 2017 ACM International Conference on Management of Data, 1085-1100

available, whilst comparing their characteristics under several benchmarks. One of the main observed issues at the time, still persisting today, is scalability, pertaining to the framework architecture or the consensus algorithms utilised, with proof of work being the most resource intensive. Current research is focused on solving scalability limitations by examining mainly mining and block size, as well as consensus algorithms whilst maintaining a secure-by-design architecture.

2.1.2. Blockchain and transport

Blockchain technology was introduced with Bitcoin and other cryptocurrencies and was initially considered as a tool for financial transactions. In subsequent years however, especially with the addition of smart contract functionality, there was a shift in perception culminating in 2015 with an announcement of the World Economic Forum that blockchains will be facilitating at least 10% of the global GDP by 2027[9]. The European Union is following suit, investing €340m in blockchain technology research between 2018-2020[10], whilst establishing important initiatives like the European Blockchain Partnership (EBP), the European Blockchain Services Infrastructure (EBSI) and the EU Blockchain Observatory and Forum. Blockchain technologies are now found in many research and market applications, though still at its infancy, ranging from the Energy, Healthcare, Financial and other sectors.

The transport sector is also examining vigorously the application of blockchain frameworks within its multifaceted landscape. In fact, a concept paper released by the University of Sheffield in June 2018[11] examined several use cases to identify how blockchains, as part of the distributed ledger technologies, can disrupt the sector. Such use cases included Mobility as a Service (MaaS), freight and logistics, Unmanned Aircraft Systems (UAS), data sharing and Collaborative Digital Transport Engineering (CDTE) identifying several value propositions, key beneficiaries and key challenges that have to be addressed.

The International Transport Forum[12] in its Corporate Partnership Board Report, "Blockchain and Beyond: Encoding 21st Century Transport"[13], issued on the 16th of May 2018, addressed issues in the field of *Mobility as a Service in a networked and meshed world* and blockchain, identifying fertile ground for identity management, security enhancement, process automation and others. On the other hand inherent issues of blockchains were also addressed such as scalability, data syntax and sharing and interoperability aspects.

Apart from institutional interest and approaches industry initiatives have also been formed. One such is the Mobility Open Blockchain Initiative[14]. MOBI is a "*nonprofit smart mobility consortium working with forward thinking companies, governments, and NGOs to make mobility services more efficient, affordable, greener, safer, and less congested by promoting standards and accelerating the adoption of blockchain, distributed ledger, and related technologies in the mobility industry*". According to MOBI "*Blockchains will increasingly impact the provision of mobility services since it enables business networks*

[9] Espinel, V., O'Halloran, D., Brynjolfsson, E., & O'Sullivan, D. (2015). Deep shift, technology tipping points and societal impact. New York World Economic Forum – Global Agenda Council on the Future of Software & Society (REF 310815)

[10] https://ec.europa.eu/digital-single-market/en/blockchain-technologies

[11] Carter, C., & Koh, L. (2018). Blockchain disruption in transport: are you decentralised yet?. Concept Paper, Transport Systems Catapult – Blockchain Disruption in Transport

[12] https://www.itf-oecd.org/

[13] https://www.itf-oecd.org/blockchain-and-beyond

[14] https://dlt.mobi/

to reduce the cost of coordinating their activities". The initiative showcases an impressive roster of partners including but not limited to the BMW Group, General Motors, IBM, Accenture, Ford, the World Economic Forum, Hyperledger Org., IOTA and others indicative of the sectoral interest in the technology and its future applications. Another initiative is the Blockchain in Transport Alliance, BiTA[15], boasting 500 members in over 25 countries coming mainly from freight, transportation, logistics and affiliated industries. BiTA is mainly focused on driving adoption via fostering collaborations and education on blockchain technologies among its members.

The utilisation of the technology takes several forms across the board of transport sector stakeholders. IBM has joined forces with Maersk to facilitate use cases across global supply chains[16]. Walmart, the US retail giant has taken steps to securing intellectual rights on a blockchain based delivery management systems, according to a filing published[17] by the U.S. Patent and Trademark Office (USPTO) on July 5, 2018 . EY has launched Tesseract[18] a blockchain based mobility platform "*built around fractional ownership of vehicles, multimodal transportation integration and new investment models*" showcasing its strategic vision in the field.

Smaller players and startups come into play too with Quasa[19] proposing a more open architecture for the supply chain, whilst others like Darenta[20], HireGo[21],Helbiz[22] and Sharering.Network[23] attempt to solve the car sharing puzzle with token economics across decentralised car sharing networks. Overall blockchain technology is still striving to find its place in the transport sector, with the potential benefits summarised in three key areas:

- Trust – blockchain technology, due to its characteristics, can facilitate trust among disparate entities, with transactional activity being logged in an irreversible and immutable manner
- Coordination – smart contracts stand to automate the execution of cumbersome logistical processes securely, reducing costs for transport sector service providers
- Information exchange – coupling blockchain with other technologies like on-board sensors, 4G/5G, machine learning, big data etc. can greatly optimise secure information exchange among people, vehicles and infrastructure.

Even though many of the current market activities will most probably fail to materialise, vested actors will gain valuable insights into the application of blockchains, preparing them for future adoption. Furthermore, research efforts are still important to address technology shortcomings and be able to support real world transport service scenarios on a large scale. Two of the main currently identified bottlenecks include:

- Scalability- commonly indicating difficulties in scaling the number of transactions per second, thus enabling transaction heavy applications to materialise efficiently.

[15] https://www.bita.studio/

[16] https://www.ibm.com/think/fintech/maersk-and-ibm-form-joint-venture-applying-blockchain-to-improve-global-trade-and-digitize-supply-chains/

[17] https://goo.gl/qcdV6j

[18] https://www.ey.com/en_gl/automotive-transportation/tesseract-blockchain-integrated-mobility-platform

[19] https://www.quasa.io/platform/overview

[20] https://darenta.io/

[21] https://www.hirego.io/

[22] https://www.helbiz.com/

[23] https://sharering.network/en

Mining costs – referring to the electricity cost of mining a single block. This is mainly due to the consensus algorithms used and trade-offs between low mining cost and security. Proof-of-work algorithms currently in use by popular public blockchain networks, like Ethereum and Bitcoin, drive costs up as the chain of blocks increases, whilst least resource intensive ones facing vulnerabilities.

2.2. Transport sector - market status and innovative models

The transport sector is undergoing a process of massive transformation. One that is amplified by developments in enabling technologies such as vehicle connectivity, machine intelligence and autonomous control, and shaped by recent developments in consumer habits evident in the rise of the sharing economy and in the public's growing appetite for on-demand services.

In this section we look at some of the major trends setting the scene for what is to come next in the sectors of transporting goods and transporting people and introduce key concepts that are central in understanding the rationale and outcomes of this technology commercialisation study.

2.2.1. Transport of goods

Transport of goods is an ecosystem in transition. Digitisation and new asset models are driving major changes within the sector. In a 2017 study, Deloitte predicts a decline in the sales of heavy and medium commercial vehicles through to 2026, but analysts also expect this shrinking fleet will move 27% more goods in 2027 than it did in 2016[24]. Demand for goods shipping is growing - fueled primarily by a growing volume of online sales. In tandem, the ability of transport networks to meet shipping demand more efficiently is also growing.

New technologies and market dynamics are reshaping every stage of a product's journey - especially the last mile. Last mile delivery providers are under pressure to move an increasing volume of goods through their network and need to optimise their processes for both delivery and pick-up of goods - the latter driven not only by the increase in online sales volumes (and the associated increase in product returns) but also by retailers' growing adoption of the free product returns service model. But the single most pressing requirement for last-mile delivery providers is speed.

Express shipping has historically been the driver of innovation in logistics. In line with this tradition, fast shipping in the form of same day delivery has been recognised as "the next evolutionary step in parcel logistics"[25]. A 2016 Deloitte study[26] found that most customers considered "fast shipping" to be within two days, while just a year earlier, in 2015, most participants in a survey said it was within three or four days. Consumer demand for speedier delivery is accelerating.

Looking at the broader picture, the convenience features which customers prioritise in relation to last mile delivery are:

- alternative pickup and delivery options (e.g., parcel locker-boxes)
- flexible delivery timing (i.e. scheduled/deferred delivery)
- delivery speed (i.e. instant, same-day, next-day delivery)

In recognition of the opportunity that last mile delivery represents, venture capitalists have gone "all in" with urban delivery startups. Companies introducing innovations in the

[24] Deloitte (2017). The future of freight: How new technology and new thinking can transform how goods are moved

[25] McKinsey & Company (2016). How customer demands are reshaping last-mile delivery

[26] Deloitte (2016). Deloitte Holiday Survey: Ringing in the retail

go-to-market approach and logistics model of last mile delivery have attracted almost USD 5 billion in venture capital since 2014 in western markets alone and are transforming the urban delivery landscape[27].

Established companies who are stakeholders in this space haven't been simply watching these developments. In recent years an increasing number of companies have started piloting and operating new models of same-day delivery, including incumbent logistics providers such as DHL, DPD, FedEx, and UPS. Demand is expected to increase significantly given the compelling value proposition of same-day delivery for consumers.

Despite the fact that incumbents and startups are racing to claim a position in this exploding market, there are many skeptics who believe same-day delivery will not be a viable model in the near future[28]. In reality, it is only technologically advanced retailers and logistics providers who will be able to offer same-day delivery soon[29]. This is because, in the current market environment, four prerequisites need to be fulfilled to enable same-day delivery and flexible last-mile capability:

- First, products need to be locally available.
- Second, retailers need to have a real-time overview of their inventories.
- Third, the picking and packing processes need to be fast.
- Fourth and finally, last-mile delivery needs to be flexible enough to pick up and deliver orders ad-hoc or multiple times throughout the day.

Despite the very real operational challenges outlined above, another limiting factor for near-term market adoption of same-day delivery services is consumer value perception. Despite the fact that customers' expectations with regards to delivery speed have increased, their willingness to pay for fast shipping seems to have fallen, with 64% reported to be unwilling to pay anything extra for two-day shipping[30]. At present time, delivery customers seem to perceive speedy shipping as something they would like to have provided it doesn't cost them extra.

In line with this analysis is also the observation that the main category that urban delivery start-ups play in is prepared food – a market with high gross margins and urgency which presents a natural fit for on demand delivery. Indeed, the new set of on-demand urban delivery providers that has entered the B2C delivery market seem to have found success in the niche of prepared food delivery. Start-ups including Deliveroo or Foodora in Europe and Postmates or DoorDash in the US, are integrating demand aggregation via their own mobile platforms and dedicated in-house operations to enable (almost) instant delivery.

2.2.2. Transport of people

The sharing economy is transforming markets around the world and markets for mobility of people are no exception. We are witnessing a shift in consumer mindset, transitioning from prioritizing vehicle ownership to prioritizing vehicle usage. In a 2016 survey of 16,469 consumers across 16 countries, which was carried out by IBM[31], 40% of respondents were very interested in subscription pricing, while another 25% of respondents were very interested in fractional ownership of vehicles.

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[27] McKinsey & Company (2017). The urban delivery bet. USD 5 billion in venture capital at risk

[28] Business Insider (2016). Don't expect same-day delivery anytime soon

[29] McKinsey & Company (2014). Same-day delivery: The next evolutionary step in parcel logistics

[30] Deloitte (2016). Deloitte Holiday Survey: Ringing in the retail

[31] IBM (2016). A New Relationship, People and Cars

According to Accenture[32], shared mobility through car-sharing and ride-hailing models will be a key driver of growth and profitability in tomorrow's auto markets, far outstripping the profitability potential of traditional car manufacturing. Accenture research supports the view that by 2030, revenues from manufacturing and selling vehicles (around €2 trillion) will be only marginally higher than they are today, and that profits from car sales will even shrink slightly (from approximately €126 billion to €122 billion). By contrast, revenues from mobility services are projected to soar to almost €1.2 trillion - with profits reaching as much as €220 billion.

We can distinguish between three alternative models of shared mobility:

- Ride-hailing
- Ride-sharing (car-pooling)
- Car sharing

Ride-hailing services such as those pioneered by Uber, which is now present in almost 700 cities worldwide, enjoy widespread adoption. Uber is the market leader in the US and Didi Chuxing is #1 in China. These two companies are the dominant players in the ride-hailing market with close to 90% of the global market by revenues, while Lyft is the global #3, with operations currently confined to the US. On a market sizing analysis, Goldman Sachs predicts that ride-hailing is set to overtake and ultimately eclipse taxi markets, while the ride-hailing market will grow eightfold to $285 billion in 2030[33]. Autonomous cars may significantly disrupt the current ride-hailing ecosystem. The business opportunity of providing autonomous fleets to ride hailers would open up a new and even bigger revenue pool than that of ride hailing itself.

The alternative shared mobility model of car sharing is also growing fast, fuelled by growing consumption demand and competition between OEMs and start-ups. A study by ING Economics Department[34] reports that 30% of Europeans with a driving licence show interest in car sharing. Boston Consulting Group predicts that, by 2021, 35 million car sharing users will book 1.5 billion minutes of driving time each month and generate annual revenues of €4.7 billion. Europe will be the biggest revenue-generating region, followed by Asia-Pacific and North America. Car sharing will reduce worldwide vehicle sales by approximately 550,000 units by 2021 and cause a net revenue loss to OEMs of €7.4 billion[35].

The Carsharing Outlook study by the Transportation Sustainability Research Center at UC Berkeley reports that the number of countries in which car sharing service are present has increased from 35 in 2014 to 46 as of October 2016[36]. The same study reports that by October 2016 car sharing organisations were active in 2,095 cities worldwide, with a fleet over 157,000 vehicles and 15 million members. Asia was by far the largest car sharing region with over 40% of all car sharing vehicles operating there. Europe was the second largest car sharing market with 37% of the global fleet.

We can distinguish between two alternative car sharing models, each of which can be further analysed in variant submodels:

- Centralised car sharing services by single organisations operating an owned fleet
- Decentralised car sharing services by networks of entities who share vehicles

[32] Accenture (2018) Mobility as a Service

[33] Goldman Sachs (2017). Rethinking Mobility

[34] ING (2018). Car sharing unlocked

[35] Boston Consulting Group (2016). What's Ahead for Car Sharing

[36] Shaheen, S., Cohen, A., & Jaffee, M. (2018). Innovative Mobility: Carsharing Outlook. UC Berkeley: Transportation Sustainability Research Center

Examples of centralised car sharing services are those provided by large OEMs like BMW ReachNow, Daimler Car2Go but also traditional car rental models such as those operated by Avis and Hertz or smaller car rental companies. These can be further broken down to station-based/round-trip car sharing services like Zipcar which is a wholly owned subsidiary of Avis, Communauto or Maven, and free-floating services such as the aforementioned car2go, DriveNow or Gig. Unlike with traditional car rentals, customers of such services rent cars for short periods of time (by the hour or minute) from collection points generally within cities. In the majority of car sharing fleets, cars must be returned to designated collection points (stationary car sharing). Alternatively, in the growing segment of 'free-floating' car sharing services, users can drop off cars anywhere within specified urban areas.

Daimler was the first company to offer free-floating car sharing worldwide and on a global scale. Car2Go was founded in 2008 and currently offers service in 26 cities, the majority in North America and Europe, with one city in China. Car2Go used to run an additional 11 cities that were all shut down for different reasons between 2014 and 2016. Car2Go's total fleet size is just under 14,000 vehicles and almost twice as big as the next biggest competitor: BMW's DriveNow/ReachNow program. Three of the European cities are all-electric and free-floating: Stockholm, Madrid and Stuttgart[37].

BMW was the second car manufacturer that invested in car-sharing, in particular in a B2C free-floating program. In Europe BMW's program is called DriveNow, in North America ReachNow. The main difference is the technology stack supporting each of the regions, the North American operations is powered by Ridecell whereas Europe runs on Sixt's platform. Combined DriveNow/ReachNow offer over 7,600 vehicles in 14 cities: the majority in Europe. ReachNow used to operate in Brooklyn but closed that city in May 2018 because of high operational costs (vehicle damage)[38].

Decentralised car sharing services are peer-to-peer (P2P) models which allow car-owners to make money by letting out their own cars for short periods of time. Peer-to-peer car sharing is much more common in the UK, the Netherlands, Germany and other parts of Europe, but it is the fastest growing car sharing business model in the United States. Examples of this service model include Turo, Getaround, Drivy, Snappcar, Sharoo and Daimler-owned Croove.

Turo is the biggest of the six P2P providers in North America. Turo announced that they have 170,000 privately owned vehicles on their platform and four million members. As of 2016 they have expanded outside the United States to Canada and later the same year to the UK. In January 2018, they announced expansion to Germany. Turo has been viewed as one of the hottest transportation start-ups with a valuation of $311 million in 2015. According to a report by Movmi[39], part of Turo's success is an extremely simple user experience for the owner of the vehicles: there is no hardware installation required (unlike many other P2P providers such as Getaround, Sharoo etc), a smaller commission compared to the competition (10-35%) that corresponds with the driver's choice of the amount of Turo insurance coverage they'd like and the ability of the owner to set their own rental prices.

Getaround is a competitor to Turo that launched to the public in May 2011. The company operates in 66 cities and has partnerships with Toyota, Mercedes-Benz, and Uber. In August 2018 Getaround announced an investment of $300 million into the company, led by Softbank. What is most compelling about the company according to Softbank's Vision

[37] Goldman Sachs (2017). Rethinking Mobility

[38] Movmi (2018). Carsharing Market Analysis - Growth and Industry Analysis

[39] Movmi (2018). Carsharing Market Analysis - Growth and Industry Analysis

Fund is the hardware system it built to allow people to rent out their cars without having to personally hand over their keys[40].

The leading car sharing service in Europe is Drivy. Founded in 2010 and headquartered in Paris, Drivy is currently present in six countries. As of 2017 it had 1.5 million users in France, Germany, Spain, Austria and Belgium and was entering the UK market. The company has raised more than $45 million in total, to support its effort to become the largest car rental marketplace in Europe.

[40] Fast Company (2018). SoftBank revs up peer-to-peer car sharing with an investment in Getaround

3. Product discovery methodology

3.1 Purpose of product discovery

Several factors come into play when attempting to discover the properties of what would represent a compelling product for a compelling market. Fundamental issues need to be addressed in order to guide a structured approach to product discovery. These pertain to knowledge gaps with regards to the market and consumer intent to uptake a proposed solution.

A core premise is that there is no crystallised knowledge in advance as to which markets are ripe for adopting new solutions. Even if the market is identified, the details of the problems cannot be known without a deep dive into the intricacies that dictate the need for a solution. As such, the range of solutions that can be proposed is wide enough to indicate that not all of them are fitting or destined to lead to an adequate problem/solution fit. Thus, prior to investing in product development, there is need for concrete evidence that building a specific product will not be a wasted effort.

To fully frame a solution and proceed with implementing a minimum viable product, ideas must be placed in front of real users and customers early and often. When this idea validation process reaches a saturation point then enough data are there to suggest a promising problem/solution fit and justify the required effort for product development. The overarching goal of product discovery is minimising risk and is based on the following three pillars:

- **Value Risk** – Will the targeted audience choose to buy the proposed solution?
- **Feasibility Risk** – Does the team have the skills and resources to build it?
- **Business Viability Risk –** Will the proposed solution and revenue model prove to be financially viable for our business?

This leads to a clear need of a structured product discovery methodology that can provide all the necessary information and indicators of potential success, to drive product development and initial market entry.

3.2 Agile process for product discovery (Lean Startup Methodology)

One of the most prominent product discovery methodologies, which is commonly used by startups around the world is based on an agile process as put forth by the Lean Startup methodology first proposed in 2008 by Eric Ries, which outlines hypothesis-driven experimentation, iterative approaches and validated learning.

In short, the Lean Startup methodology can be divided into two distinct phases depending on the stage of development. These are the "Search" phase, where enough evidence must be gathered to justify future actions, and the "Execution" phase, which builds upon evidence to build and potentially scale an appropriate solution, as shown in the following figure.

The "Search" phase is focused on discovering an appropriate problem/solution fit and was the focus of the project. There are two key activities foreseen which include "Customer Discovery" and "Customer Validation". The process followed in both cases and under the prism of the Lean Startup methodology are ideation on the path to be followed, concepting on the experiments to take place and subsequently by screening and learning from the results to adjust the approach.

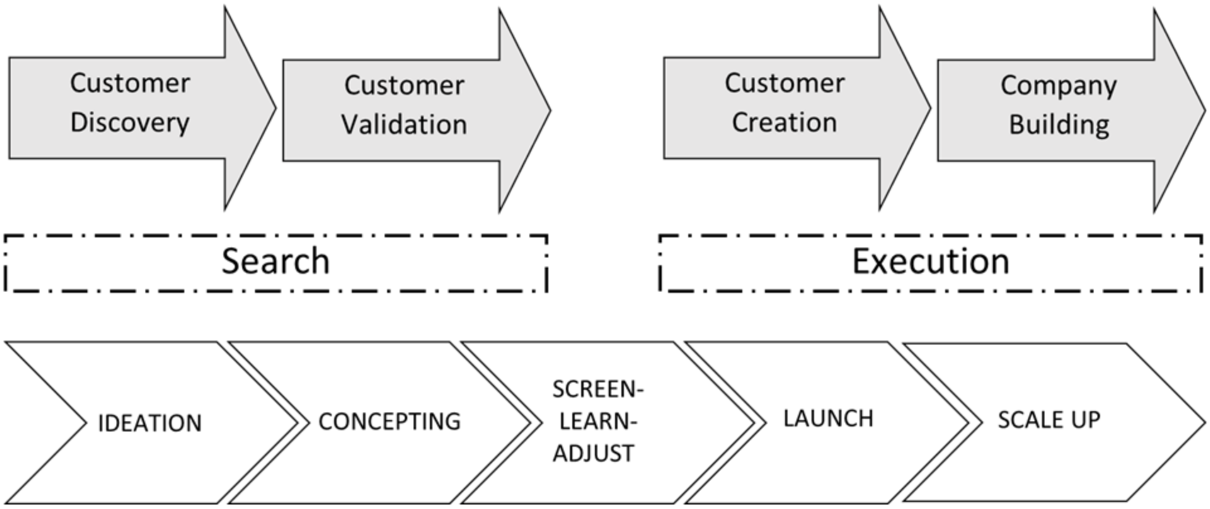


Figure 2. Lean start-up methodology

Customer Discovery aims to provide answers to fundamental assumptions that need to be addressed in order to characterise in a comprehensive manner the most promising path towards identifying compelling value to a compelling market. Such questions include:

- ***Need identification*** - What is the customer's level of pain?
- ***Need alleviation*** - What are the possible solutions?
- ***Beachhead Market & Persona identification*** - Who is the first customer?
- ***Adoption criteria*** - How does the customer react to the proposed solution?
- ***Competition (solutions or habits)*** - How do customers solve the problem today? Do they do anything? What is it?

Once basic assumptions have been tested and there is sufficient data to justify a solution proposal, then customer validation follows.

Customer Validation builds upon the learnings of the customer discovery process to propose a minimum viable product (MVP) which commonly entails things like a landing page for potential customers to express their intent to buy the solution, a mockup that shows how the solutions solves their main problem or even a limited featured product for them to pilot. This initial draft offering aims to solicit their reactions or responses in such questions like the following:

- What are their reactions to the MVP?
- Would customers use the product? Would they be interested in a demo / pilot?
- Are they willing to buy the product? If yes, at what price?
- Which of the product characteristics are they most and least interested in?
- Are there other factors that would influence their decision to buy?

3.3. Product discovery approach

According to the agile product discovery process outlined by the Lean Startup methodology, the research team followed a step by step approach to collect the required evidence that can justify a problem/solution fit, addressing the transport and mobility sector that includes blockchain technology, as outlined by the project objectives. An outline is graphically represented in the following figure.

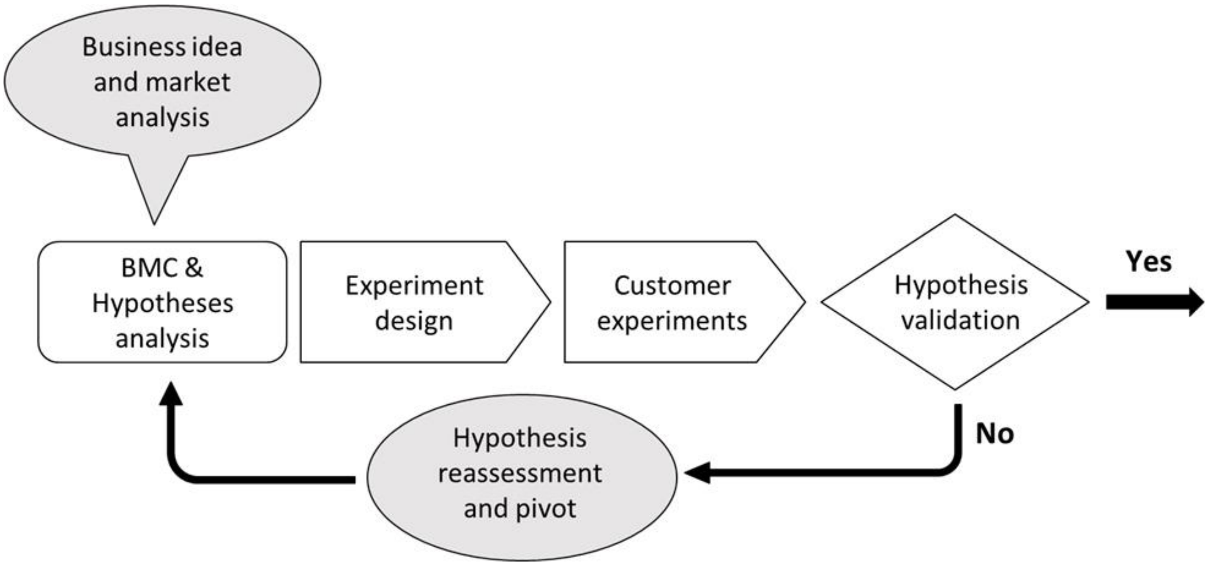


Figure 3. Product discovery approach

The steps included: framing the market, assessing the opportunity, understanding business value and testing it to the targeted market niche. Each step had to identify "why" and "how" in order to justify satisfactory value and subsequently lead to the next step of the process.

Market framing aimed at building a deeper understanding of the market. This was achieved via thorough market evaluation based on desk research including analysis of market reports, publications and patents, and field research based on a first round of semi structured qualitative interviews with identified market stakeholders.

Opportunity assessment followed pace in the scope of narrowing down and focusing on promising market segments. This was achieved after thorough analysis of the data collected from previous online and offline research activities.

Business value ideation was the succeeding step in the process, which aimed at producing distinct value propositions for the identified market niche. The Business Model Canvas lean startup template was used in this step to characterise and record a top level business model corresponding to a proposed solution offering and how it would fit within the frame of business processes.

Value testing activities was the final step in the process aiming at minimizing the associated risks with future product implementation. In order to assure most prominent risk factors are thoroughly examined, a set of assumptions was drafted and mapped according to impact on business viability and level of uncertainty as to the factors that come into play or knowledge required. These assumptions fed a set of experiments including online questionnaires and a second round of semi structured qualitative interviews, appropriate marketing landing pages to identify customer interest and a final project landing page, video presentation and pitch deck.

4. Application of the methodology and outcomes

The following sections summarise the activities undertaken and the outcomes derived from applying the methodology outlined in section 3. Our presentation of the results aims to justify the selection of the niche market being proposed by the research team, its characteristics and the interest of market stakeholders involved in the product discovery process.

4.1. Market framing

Framing the market to be addressed involved market research with the aim of the current market status, models, trends and underlying problems and drivers. It also included a first round of a limited number of open qualitative interviews with expert professionals in the transport sector to confirm or enrich the preliminary findings. The outcomes where then weighted based on the available expertise and potential unfair advantages.

The transport sector was initially split between "transport of goods" and "transport of people" as indicated in section 2.2 and as foreseen by the original project scoping document/proposal. Based on publicly available market research reports, both of these sectors present several opportunities for growth and new innovative business models, including leveraging new technologies to tackle current issues. Market framing however aimed at highlighting the characteristics of each market and not addressing the opportunities that lie within.

4.1.1. Service Models in the Market

Table 1 presents the market service model analysis in the frame of "transport of people" focused on car sharing models, whilst the "transport of goods" focused on last mile delivery.

Shared mobility service models address all forms of transport options for people including:

- Ride-hailing - with prominent companies employing innovative approaches, like Uber with a €62b capitalisation value, Lyft valued at €13.2b, and even car manufacturers like Daimler AG which has acquired several ride-hailing companies in Europe and abroad over the past few years.
- Ride sharing - including companies like the French owned BlaBlaCar, generating over €80m in revenues annually.
- Car sharing - which can be divided into centralised and decentralised models. Centralised car sharing models are represented by offerings from companies likeAvis, Hertz and local SMEs and side offerings like ZipCar, a subsidiary of Avis Budget Group. Within this space several efforts are working towards more innovative models such as free-floating car sharing. ReachNow and Car2Go by the Daimler AG and BMW Group collaboration are paving the way in this respect. The decentralised peer-to-peer landscape is currently represented only by start-ups, established or upcoming, like Getaround, Turo, Drivy, Snappcar and others, whilst professionals who commonly practice subletting between peers do not have access to dedicated ICT tools.

Last mile delivery service models address delivery options including:

- Deferred Delivery & Next Day Delivery – mature services typically represented by known market actors like UPS (currently under a merger with TNT), FedEx as well as a plurality of national or regional carriers.
- Same Day Delivery (SDD) –includes more innovative delivery models and seems to be a level-playing field for established carriers and upcoming start-ups alike. Examples include Amazon's Prime service, offering SDD within range of its

fulfilment centres[41], Dada serves Walmart's SDD in China[42] in collaboration with WeChat, while Instacart is partnering with local groceries in a number of US cities[43].

However, a closer look to the data shows that the European market holds a significant share of mobility of people services outperforming mobility of goods making it an attractive target market. Furthermore, the growth rates of markets related to transport of people are outpacing the corresponding growth rates of transport of goods. In line with the above, **Table 2** and **Table 3** further outline the characteristics within these markets.

Table 1. Analysis of service models in the market – passenger vs goods transport

Shared mobility (transport of people)[44]	**Last Mile Delivery (transport of goods)**[45]
Market size 2016: $54b (EU: $6b)	Market size: $70b (EU: $3b in 2020)
Annual Growth Rate: est. 28%	Annual Growth Rate: est. 15%
Service models:	
Ride-hailing	Deferred delivery
Ride sharing/Car pooling	Next day delivery

Car sharing
• Centralised (Managed Fleets)
  ○ Station-based
  ○ Free-floating
• Decentralised (peer-to-peer)
  ○ Individuals
  ○ Professionals
	Same day delivery

[41] https://www.amazon.com/Prime-FREE-Same-Day-Delivery/b?ie=UTF8&node=8729023011

42 https://techcrunch.com/2018/11/20/walmart-in-china-is-now-testing-same-day-grocery-delivery-from-dada-via-wechat

43 https://www.instacart.com/

[44] " McKinsey & Company (2016). How shared mobility will change the automotive industry", McKinsey & Company, 2016

[45] " McKinsey & Company (2014). Same-day delivery: The next evolutionary step in parcel logistics", McKinsey & Company, 2014

Table 2. Shared mobility European market characteristics

Shared Mobility[46]	Distance	Degree of flexibility	Stakeholders	Cost
Station-based car sharing (mature model)	Mid	Low	Established	High
Free floating car sharing (market ready model)	Mid	Mid	Established, internal innovation	Mid-High
P2P car sharing (initial market insertion)	Short	High	Startups	Mid-Low

Table 3. Last Mile Delivery European market characteristics

Last Mile Delivery[47]	Time	Type of delivery	Stakeholders	Cost
Deferred delivery (mature model)	3 - 5 days	mail-order	Established	Tiered
Next day delivery (mature model)	1 day	e-commerce	Established	Tiered
Same day delivery (initial market insertion)	1-12 hours	SDD	Established, start-ups, retailers	Optimisable

4.1.2. Consumer Demand Indicators

Exploring both sectors and their respective market reports, underlined trends and consumer preferences and characteristics have been identified. In the case of last mile delivery where very mature models exist, market research studies have been entirely focused on same day delivery (SDD) models. The reports tried to capture current and future indicators with the most prominent included in Table 4.

As the reported data suggest, shared mobility holds higher interest and intent by consumers probably due to the fact that it affects basic transportation needs and on-demand mobility habits. Same day delivery on the other hand would be a desirable offering but is not considered as covering a crucial need or offering a highly valued service.

[46] Monitor Deloitte (2017). Car sharing in Europe: Business Models, National Variations and Upcoming Disruptions

[47] McKinsey & Company (2014). Same-day delivery The next evolutionary step in parcel logistics

Table 4. Market trends comparison Shared Mobility vs Same Day Delivery

Shared Mobility[48]	Last Mile Delivery (focus: Same Day Delivery offerings[49])
Increase of usage intent in e-hailing services in the future: **63%**	Consumers are willing to pay more for same-day delivery: **61%**
Increase of usage intent in car-sharing services in the future: **67%**	Shoppers want same-day shipping: **80%**
Users would try autonomous driving when using car sharing: **68%**	Consumers (UK,FR,DE,SE) that think Same Day Delivery serves a real need: **27%** Consumers (UK,FR,DE,SE) that think they would definitely use an SDD service: **14%**

4.1.3. Barriers to Fulfilling Consumer Demand

Having already looked at the status of the two most vibrant markets in the transport sector (shared mobility and last mile delivery) and having identified the most prominent consumer preferences driving developments within each market, the next step is to look closer at the challenges faced by businesses active in each market.

To identify potential fields of opportunities that the project could address, further analysis was conducted with regards to the problems that arise in each market. These mainly revolved around procedural and pricing issues that stand to affect business processes as presented in **Table 5**.

In terms of shared mobility there are evident problems with capital expenditure affecting fleet flexibility, pricing models currently in place and lack of ICT tools for professionals. Conversely in same day delivery, where operational costs dictate viability, there seems to be lack of processes on behalf of retailers coupled with lack of capacity handling by courier services, hence forcing them to focus on niches and local markets. In addition within the frame of typical hub-and-spoke infrastructures which are optimised for next day delivery, same day delivery is not foreseen, evidently affecting pricing models and rendering such options of higher cost and difficult to uptake.

[48] McKinsey & Company (2017). How shared mobility will change the automotive industry

[49] McKinsey & Company (2014). Same-day delivery The next evolutionary step in parcel logistics

Table 5. Potential problems in shared mobility and last mile delivery market

Shared Mobility	Last Mile Delivery
Fragmentation of the landscape (ownership of assets)	Fragmentation of the landscape, too many stakeholders
Lack of availability of these solutions in rural settings	Processing, fulfilling, and delivering an order within a few hours requires new types of networks
Sharing tends not to favour frequent commuting due to its cost	Current processes used by parcel logistics providers are not suited to same-day delivery at scale
Car sharing is rarely economically viable in cities with fewer than half a million inhabitants	More flexible city couriers are too small to deal with large retailer volumes
Some models are asset intensive (managed fleets)	Some models are asset intensive (managed fleets)
Lack of tailored pricing models	Lack of tailored pricing models
Driver insurance models can become cumbersome	Hub-and-spoke are optimised for next day
No ICT tools for sharing of assets among professionals	Narrow focus from current offerings, typically oriented in local market

4.1.4. Comparative Evaluation

Both markets exhibit significant drivers for adoption. The case for shared mobility is strongly driven by consumer preferences worldwide and subject to face significant changes in the future with the advent of autonomous driving technologies. Sustainability issues are represented by a changing regulatory field addressing vehicle ownership and emissions' taxation, lowered limits of fleet ownership for car-sharing operators, whilst lower sales drive traditional car industry players into considering diversified "as-a-Service" models complementing their offerings and revenue streams. To this end, open access to cutting edge technology frameworks like artificial intelligence and distributed ledgers (e.g. blockchains) level the playing field supporting more and more actors to create innovative offerings. On the other hand same day delivery seems to be gaining its place in the last mile delivery landscape driven by customer preferences and gaining importance due to the rising share of online retail. Lower costs and fast paced lifestyle in urban settings drive consumers to further uptake of SDD options, providing fertile ground for future growth.

The process of defining a compelling product for a compelling market demands focus. In a preliminary effort to select between the two transport markets, three basic criteria were considered, namely market growth indicators, entry barriers and the available expertise.

Market growth is an important criterion because it significantly influences the size of the opportunity that a new product could potentially capture. The presence of barriers to entry in a market is also critical because they greatly affect how much capital and other resources will need to be deployed to the product development effort. Lastly, the expertise of the team that supports the development of a new product is also critical because if can provide an "unfair advantage" in a future product or solution proposition. In summary, the criteria and indicators are as presented in **Table 6**.

Table 6. Market growth, entry barriers and internal expertise

Criteria	Shared mobility	Last mile delivery
Market growth	• **CAGR ~28%**	• CAGR ~15%
Entry Barriers	• Shared mobility is a mature model • Several shared mobility services are already established • New solutions are launching, gaining traction and congesting the competitive landscape	• Several last mile delivery services are already established • Multi-stakeholder environment with increased complexity • Hub-and-spoke infrastructure is optimised for next day delivery
Internal Expertise	• **JRC team has a stronger background in passenger transport** • **JRC has access to mobility sector stakeholders**	

In conclusion, there seem to be more clear indicators in favour of further examining the shared mobility sector. Considering the team's available expertise, the higher rates of annual growth and market adoption of shared mobility solutions and the research findings on consumer intents and preferences, we are encouraged to take a deeper dive into assessing the opportunities that lie ahead in shared mobility.

4.2 Opportunity assessment and competition analysis

4.2.1 Opportunity assessment

Market framing has provided clear indicators on the potential of the shared mobility market. It showcases a high Annual Growth Rate and new innovative models are currently being field tested and offered with significant initial traction. Traditional industrial stakeholders like Daimler and BMW are already successfully operating shared mobility services and plans of consolidation indicate strong drivers for growth. Furthermore, shared mobility falls directly within the research team's available expertise and market access potential.

Following that, a viable niche, a well-defined market often called a beachhead, had to be identified, which would benefit from the enablers blockchain technology has to offer in the shared mobility landscape. The goal was to discover the properties of what would represent a compelling product for a compelling market. To do so, three questions had to be answered, pertaining to (i) which mobility service model, (ii) which type of model characteristics and (iii) which beachhead market would benefit the most out of enhanced trust, process coordination and information sharing.

Each question had to indicate all available options, take under consideration specific decision criteria and result in a verdict based on market insights so far and blockchain technology strengths.

Which mobility service model?

Options: Ride hailing vs ride sharing vs car sharing

Decision criteria: Importance of information sharing, process coordination and trust to each model.

Verdict: Considering the fact that the transfer of assets among disparate partners is prominent in the car sharing model, enhanced trust and coordination along with reliable information exchange is paramount to drive growth in this market segment and facilitate diversified business models.

Which type of car sharing model?

Options: Centralised vs decentralised car sharing

Decision criteria: Which market would be more impacted by the use of BC technology?

Verdict: BC technology was purposefully designed to offer unique benefits to decentralised networks comprising disparate entities. As such the technology is directly suited to peer-to-peer car sharing models, where trust, coordination and reliable information stand to greatly affect solution uptake.

Which beachhead market?

Options: Consumer to Consumer (C2C) or Business to Business (B2B) decentralised car sharing networks

Decision criteria: Which market is most compelling and would potentially uptake a proposed solution?

Verdict: Small to medium sized managed fleet owners, such as car rental companies, practice subletting as part of their daily processes in order to handle fleet flexibility over high and low seasons and increase profitability. Their market is mature but not supported by any purpose-built ICT solutions to facilitate exchange among professional peers. Subletting is based predominantly on trusted private networks, which restricts their reach and eventually their choices and on-demand responsiveness. The processes involved include tedious record keeping and insurance contracts on demand which leads to an increase of operational expenditure. Widening their network on the basis of trust, streamlining coordination and having access to information when they need it could translate to a positive welcome of a BC based solution offering. The proposed market showcases compelling characteristics, valuated at €58.26b in 2016 with an estimated CAGR of 13.5%. Closer to home the European car rental SMEs represent 35% of the entire EU car rental market at an estimated €4.2b. All of the above substantiate a compelling market that is large enough, underserved and an overall good fit with regards to BC technology. Conversely, peer-to-peer car sharing among individuals could prove an interesting niche, although several solutions are currently competing in the market either based on BC or not, hinder ease of initial market insertion. The following table outlines the logic behind the focus on professional peer-to-peer car sharing while 4.2.2 depicts the opportunity assessment tree.

Table 7. Professional peer-to-peer car sharing as principal focus area

Decentralised car sharing model	Readiness (European market)	Current market size (European market)
Consumer to Consumer (C2C) p2p car sharing Transactions between private individuals	P2P car sharing is at an early stage of adoption among consumers	Small (370,000 vehicles in 2018, just over 0.1% of all passenger cars)
Business to Business (B2B) p2p car sharing Transactions between owners of small managed fleets (car rentals & dealers)	P2P car sharing is an established practice among owners of small managed fleets	Large (annual spend estimated at €630m, or 15% of SME car rental market size)

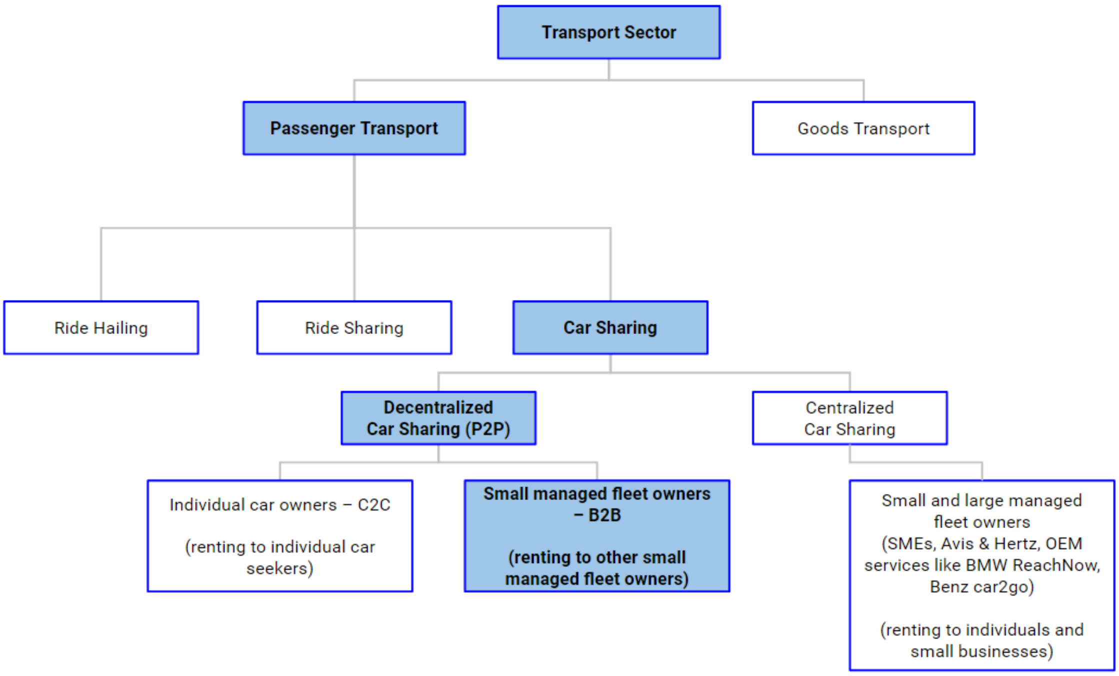


Figure 4. Opportunity assessment tree

4.2.2 Competition analysis

Analysing the competition in the decentralised car sharing space one needs to account for solutions in the general peer-to-peer space addressing individuals, solutions addressing the car rental space and particularly subletting, as well as habitual practices that could stand to hinder adoption of new solutions. Figure 5 presents a snapshot of the competition analysis matrix created in the course of this research.

	B	D	E	G	K
1					
2	Name	Segment	Web	Short Description	Stage
3	lime	Bike Sharing	https://www.limebike.com/	A dockless bike-sharing program in the Bay Area that costs $1 per ride	132$ mln in fund
4	Bird Rides	Bike Sharing	https://www.bird.co/	Bird Rides lets customers rent dockless electric scooters	115$ mln in fundi
5	ofo	Bike Sharing	https://www.ofo.com/us/en	"station-free" bike-sharing platform operated via an online mobile application	$2.2B
8	oBike	Bike Sharing	https://www.o.bike/	Singapore's first homegrown station-less smart bike-sharing company	$45M
9	Keen	Car Pooling	https://keenplatform.com/	Autonomous Ride Hailing Platform	White Paper
12	Arcade City	Car Pooling	https://arcade.city/	Blockchain based ridesharing	
13	La Zooz	Car Pooling	http://lazooz.org/	Blockchain based ridesharing	
14	Dashride	Car Pooling	https://dashride.com/	Automated ridesharing as a service	
16	Yantha	Car Pooling	https://www.yantha.com/	Blockchain-based car pooling service	Token pre-sale
17	DACSEE	Car Pooling	https://dacsee.io/#/	Fully decentralized and autonomous social ride-sharing service	ICO
19	HireGo	Car Sharing	https://hirego.io/	Decentralised car sharing platform	Pre-sales, MVP,
20	SocialCar	Car Sharing	https://www.socialcar.com/e	Nº 1 peer-to-peer car rental in Spain	
21	Darenta	Car Sharing	http://darenta.io/	Blockchain based car rental services	MVP, now on Tok
22	Helbiz	Car Sharing	https://www.helbizcoin.io/	Blockchain based car sharing solution	
27	Gitto Project	Car Sharing	http://www.gittoproject.com/	Automating the P2P car rental industry	Last tween (5 mo
29	Xain	Car Sharing	https://xain.io/	XAIN provides a standardized language for secure human to machine interactions	
30	Getaround	Car Sharing	https://www.getaround.com/	Rent great cars from people nearby	
31	Drivy	Car Sharing	https://www.drivy.com/	Cars around you, ready to go	
32	Turo	Car Sharing	https://turo.com/	Book unforgettable cars from local hosts around the world	

Figure 5. Snapshot of the competition analysis matrix

Companies like Drivy from the United Kingdom, Ouicar from France and SnappCar from Germany, along with Turo and Getaround from the United States and others are currently competing in the field of peer-to-peer car sharing space focusing on individual car owners. These companies are currently based on common technology stacks to facilitate their business models. Conversely newcomers in this field like HireGo, Darenta and Helbiz, are leveraging BC technology to augment their offering based on tokenomics and enhanced coordination. All of the above could diversify to foster the needs of professionals, albeit diverting considerably from their business models, leading to increased capital expenditure.

On the other hand one can identify several software vendors focusing on car rental companies like HQ Rental Software[50] by Caag Software or Carhire Manager Web[51] by Datalogic Consultants and others which are however focused on car rental company and fleet management rather than facilitating car exchanges amongst professionals. They could however provide car sharing features with minor adjustments, but this is highly unlikely as it would entail functionality only among the professionals currently licensing the system which would defeat the purpose of building closely tied ecosystems of peers in terms of location and market size.

A distinct offering is the one by carchain.io which is a BC based solution likely to facilitate car leasing contracts. Carchain.io however is still in its infancy as it is the result of a project that sprung from the 2018 hackathon.io competition in Munich, Germany. There is currently no clear positioning neither enough data to constitute concrete competition in the field.

Last but not least the most prominent competitor as with all new efforts are the daily practices of professionals and the inherent difficulty to adapt to new solutions and break established habits and manual processes. Break such barriers depends on the "level of pain" and cost and whether implementing a proposed solution would make financial sense, or save productive time better utilised otherwise in the short term.

Table 8 summarises the most relevant competitive landscape.

[50] https://hqrentalsoftware.com/

[51] https://www.carhiremanagerweb.com/

Table 8. Competitive landscape

Decentralised car sharing model	Competition (European market)
Consumer to Consumer (C2C) p2p car sharing Transactions between private individuals	Well-funded companies like Drivy, Snappcar, Ouicar (similar to Turo and Getaround in the US) ICO start-ups HireGo, Darenta, Helbiz
Business to Business (B2B) p2p car sharing Transactions between owners of small managed fleets (car rentals and car dealers)	Manual (not using special purpose tools). Early-stage start-ups like Carchain.io

4.3. Business value ideation

Based on the outcomes and learnings of the opportunity assessment the value proposition for the selected beachhead market, i.e. business-to-business car sharing / owners of small managed fleets, should revolve around the following key axis:

(a.) *Fleet flexibility*: via the proposed solution, car rental professionals could be able to expand their fleet, on-demand;

(b.) *Low CAPEX*: car rental companies could bring the size of their owned fleet to an absolute minimum, decreasing capital expenditure requirements;

(c.) *Network expansion*: each individual professional could have access to an expanded network of other affiliate trusted professionals and businesses;

(d.) *Efficiency*: the process of looking for cars' availability, making arrangements, and settling contracts and payments, should become streamlined and automated.

Figure 6 presents the drafted business model. The model was built in a way that could not only address the needs of the selected beachhead market, but could also be used to expand the value proposition to the consumer-to-consumer car sharing model as well, via three distinct layers:

(a.) *B2B sub-model*: this layer of the business model regards only professionals active in the car sales and/or car rentals businesses;

(b.) *Expanded B2B sub-model:* this layer regards an extended B2B model, where private individuals can offer their own cars to professionals for "exploitation", i.e. sub-renting;

(c.) *C2C sub-model:* this layer regards private individuals who can exchange private vehicles between each other.

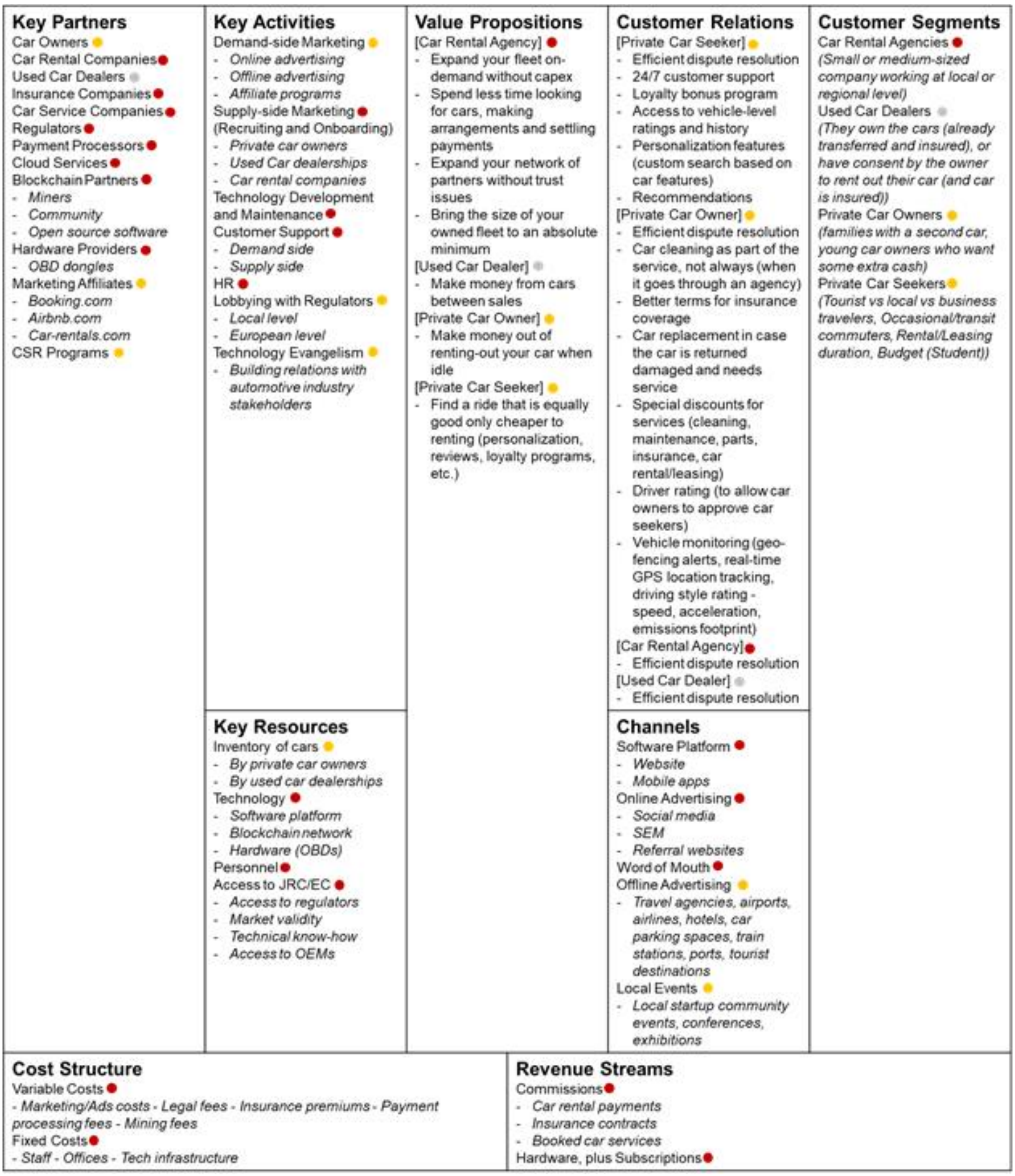


Figure 6 Business Model Canvas

The combination of the three different layers describes the complete proposed business model where peers can rent vehicles from other peers, either as private individuals or professionals in the car rentals sector.

A different colour code is applied to the business model canvas to separate information relevant to each individual layer / sub-model: yellow is for the C2C layer, red is for the B2B only layer, and grey is for both the B2B and C2C, i.e. the extended B2B layer.

4.4. Assumption definition

As outlined in section 3 the assumptions validation process demonstrates a swift from the conventional waterfall approach of product discovery used by traditional models, towards a lean, resource optimised approach, where experiments and real evidence from the potential users and the targeted market are used to de-risk the proposed business model and decision-making process regarding the business and/or product development strategy.

> "*Assumptions validation is the process of gathering evidence and learnings around business ideas through experimentation and user testing, in order to make faster, informed, de-risked decisions.*" (source: boardofinnovation.org)

Mapping assumptions and subsequently conducting small scale experiments to source valuable data aims at reducing risk. It comprises elements that, when analysed, stand to minimise uncertainty and provide strong indicators of potential success factors in all of the following three categories of risk:

- **Desirability/value risk**: the extend in which the target audience desires the proposed solution.
- **Viability risk**: the extend in which the proposed business model can be sustained by the sise of the targeted market
- **Feasibility risk**: the extend in which the project team can develop the proposed solution

4.4.1. Assumption mapping

The assumptions tested over the course of the project were drawn from its business model and were based on three main variations of the model:

- **B2B offering:** targeting only P2P car sharing activities among professionals
- **B2B+ offering:** P2P car sharing activities among professionals, plus the options for individuals to offer their cars to this network under management by car rental professionals
- **P2P car sharing marketplace:** a P2P car sharing marketplace which professionals and private car owners would use as a platform for P2P car sharing

As such the main assumptions recorded were those of considerable impact to the success of the proposed business model and of high uncertainty, based on prior knowledge of the team. The following Table includes a set of prioritised assumptions examined.

Alternative approaches have been adopted to select the various assumptions. Each individual assumption has been tested with various "experiments", while results of each experiment have been compared with each other to identify inconsistencies and/or cross-validate the respective assumption.

- Questionnaire to private car owners
- Qualitative interviews with car rental companies
- Cold calling to car rental companies to test further interest in a subletting solution
- Invitation to car rental companies to express interest for collaboration, via email and landing page MVP

Table 9 Prioritised assumptions examined

BMC box	Business model	Assumption	Impact	Uncertainty	Score
Customers	B2B	A sufficient percentage of **car rental companies** would be willing to use a software solution to manage the process of sourcing cars from a wider network of other car rental companies, under specific conditions and pricing	10	5	50
Customers	B2B+	A sufficient percentage of **car rental companies** would be willing to source a car from a private individual, under specific conditions and pricing	8	10	80
Customers	Marketplace	A sufficient percentage of **car rental companies** would be willing to use an online marketplace as a channel to rent out their owned cars, under specific conditions and pricing	8	5	40
Customers	Marketplace	A sufficient percentage of **car rental companies** would be willing to use an online marketplace as a channel to rent out cars they have sourced from private car owners, under specific conditions and pricing	4	7	28
Customers	Marketplace	A sufficient percentage of **private car owners** would rent out their car to a private car seeker, under specific conditions and pricing	8	9.5	76
Customers	B2B+ / Marketplace	A sufficient percentage of **private car owners** would rent out their car under management by a car rental company, under specific conditions and pricing	9	10	90
Customers	Marketplace	A sufficient percentage of **private car seekers** would be willing to rent a car from a private individual, under specific conditions and pricing	10	6	60
Key partners	B2B+ / Marketplace	**Car insurance companies** offer a suitable insurance model already, or are willing to create one	10	8.5	85
Cost structure	B2B+ / Marketplace	There is a sufficient profit margin between costs (stakeholders' price points) to sustain a scalable business. For instance, insurance product costs do not limit financial viability	10	8	80
Key resources	B2B+ / Marketplace	There is freedom to operate from a regulatory point of view	10	10	100

4.4.2. B2B service - Assumption validation

Semi-structured Qualitative Interviews

Peer-to-peer car sharing is common practices among SMEs in the car rental space, but desk research indicated no software solution or service addresses it. Thus, the assumption articulated aimed at identifying what this gap entails and whether a solution/offering would make business sense.

> *"A sufficient percentage of* ***car rental companies*** *would be willing to use a software solution to manage the process of sourcing cars from a wider network of other car rental companies, under specific conditions and pricing"*

To validate this assumption the following experiment was designed:

Table 10. Experiment outline

Experiment Steps	
Step 1: Hypothesis	We believe that a sufficient percentage of car rental companies would be willing to use a software solution to manage the process of sourcing cars from a wider network of other car rental companies, under specific conditions and pricing.
Step 2: Test	To verify this hypothesis we will conduct a semi-structured qualitative survey through 10 interviews with small and medium-sized car rental company owners...
Step 3: Metric	..and measure how many of the interviewees confirm the following: • Car sharing is a common practice among car rental companies • which has a real financial impact in their business • but also significant room for improvement • and car rental companies believe that widening their network would increase the revenue opportunity • and would be willing to try a special-purpose software solution
Step 4: Criteria	We will consider the hypothesis right if: • at least 50% of companies practice car sharing • car sharing represents at least 10% of their revenue (demand and supply combined) • at least 30% of car demand or car supply requests is currently not satisfied • at least 30% would be willing to practice car sharing through a wider network of car rental companies • at least 20% or more would be willing to try a software solution to help them in this process

The experiment was elaborated in a questionnaire (Annex II) to support one-on-one semi-structured qualitative interviews with car rental owners in Greece. A total of 11 interviews were conducted of which 6 face-to-face interviews took place in the areas of Thessaloniki, Katerini and Chalkidiki and 5 phone interviews in the areas of Thessaloniki, Rethymno, Chios, Skiathos and Corfu. The car rental owners interviewed managed fleets ranging from 10 to 300 vehicles.

The questions touched business processes issues as well as practices. Some of the key areas examined were the company profile and how it correlates with the project's market framing, what does car sharing as a company practice entail, the financial impact of car sharing practices, problems and room for improvement identified by stakeholders, whether widening the peer network as a solution makes business sense and willingness to try a software solution to streamline current practices. Some of the recurring themes are summarised in **Table 11**.

Table 11. Semi-structured inteview recurring themes

Recurring Themes
Fleet elasticity is common practice (rises in high season, drops in off season)
Network trust is essential, commonly limited in small groups of professionals who know each other
Pricing & cash flows, timing of payment is an issue
Demand vs. Response depends on fleet sise owned & affects vehicle availability
ICT tools are not available to support car sharing among professionals

The overall learnings from the interviews conducted showed that an estimated 20% of revenues is lost due lack of vehicle availability, approximately 30% of revenue is attributed to subrentals (demand or supply), short term rental are more financially attractive than long term rentals, fleet elasticity is highly seasonal and for small car rental companies the fleet sise can rise between 40% to 300% percent (depending on sise of managed fleet). This situation presents similar characteristics to the hotel business in terms of revenues lost once capacity is reached, a sub-rental could cost from as low as €5-€10 per day per car. In terms of market sise and revenue potential it was noted that travel agencies charge 10-15% commission, with the wider area of Thessaloniki hosting roughly 400 car rental companies. In a positive outlook it was suggested that peer effect could quickly raise the number of professionals up taking the proposed peer-to-peer car sharing solution. Overall the examined assumption seemed to be validated, considering that the following results were achieved):

- **More than 80% of car companies apply car sharing**, one way or the other (>50% goal)
- **The financial impact is** highly depended on the sise of the managed fleet but it seems that **10-15% on average** is an educated estimate (>10% goal)
- Streamlining vehicle supply and demand could lead to an increase of up to 20-40% in revenues as estimated by interviewees (>30% goal)

- **More than 80% of car rental owners would be willing to extend their network** (>30% goal)
- **More than 80% of car rental owners would be willing to adopt a software solution** to extend their network (>20% goal)

In order to further examine and solidify car rental owners' interest in the proposed solution more steps were taken that included cold-calling campaigns, email campaigns and the creation of two marketing landing pages.

Cold-calling campaign

Cold calling is a common business practice which attempts to solicit interest in a product or service from the targeted audience, without the potential customer having prior knowledge of or contact with the person conducting the call. The process relied on publicly available business contact details from Greek and Italian car rental companies and the call included the following pitch.

> *"We are a team of engineers, working on a solution that will facilitate the process of cars' sub-rentals between professionals. Would you give us your email to send you more information?"*

A total of 260 calls were conducted with the details presented in **Table 12**.

Table 12. Cold calling campaign summary

Total Cold Calls	Greece	Italy
Calls: 260	Calls: 84	Calls: 176
Replied: 122	Replied: 61	Replied: 61
Emails collected: 112	Emails collected: 54	Emails collected: 58
Conversion rate: (91.8%)	Conversion rate: (88.5%)	Conversion rate: (95.1%)

Although cold calling conversion statistics are typically in the 1-3% range[52] the response and voluntary email sharing of the respondents was considerable. Except for a small number of cases (<10%), the conversion rates are indicative of their interest in the proposed solution, further supporting the validity of the assumption.

Email campaign

Following the cold calling process an email campaign was sent out to the emails gathered, extending the initial pitching with information on what the team is working on and the value proposition. The email context prompted recipients to visit a webpage where they had the chance to express their interest for a collaboration / participation in our beta testing, via a purpose specific call to action.

[52] Khalsa M., & Illig R. (1999). Let's Get Real or Let's Not Play: Transforming the buyer/seller relationship. ISBN-10: 1591842263

To facilitate the process two marketing landing pages were developed using the Mailchimp[53] online email marketing service. The two pages presented the same set of information in Greek and Italian and are available in Annex II.

The results of the campaign are summarised in **Table 13**

Table 13. Cold-calling and email campaign results

Total (GR+IT) (unique)	No. of	Conversion rate	Conversion rate/Total
Calls conducted	260		
Calls answered	122	46.92%	
Emails collected	112	91.80%	91.80%
Emails delivered	102	91.07%	83.61%
Emails accessed	65	63.73%	53.28%
Email call to action clicks	30	46.15%	24.59%
Partnership forms submitted	**3**	**10%**	**2.46%**

Additionally, the 102 emails delivered were opened 205 times, whilst the total clicks on the call to action message were 34. The interest was similarly distributed among Greek and Italian recipients. Overall a 2.46% of the recipients submitted the partnership form at this idea stage signifying an early adopters' audience in the sector willing to investigate new and innovative solutions. Considering that this is 10% of the recipients who ended up clicking the call to action, the proposed solution seemed to attract considerable and genuine interest by the relevant stakeholders. This first set of results was encouraging, however more data and a more extended campaign would be required to reach a saturation point and thus extract solid conclusions (i.e. increasing the number of recipients visiting the landing page).

4.4.3. B2C service - Assumption validation

When addressing the service directly to consumers the most important assumption tested was the following:

> *"A sufficient percentage of private car owners would rent out their car to a private car seeker, under specific conditions and pricing"*

To validate this assumption, the experiment described in Table 14 was designed.

[53] https://mailchimp.com/

Table 14. B2C Assumptions-validation experiment

Experiment steps	
Step 1: Hypothesis	We believe that a sufficient percentage of private car owners would rent out their car to a private car seeker, under specific conditions and pricing
Step 2: Test	To verify this hypothesis we will conduct an online survey with a minimum of 100 private car owners...
Step 3: Metric	...and measure how many of the participants confirm the following: They would be willing to rent out their car at a price point "comparable" with common car rental companies, under conditions which would be "compatible" with common car rental companies' practices
Step 4: Criteria	We will consider the hypothesis right if at least 20% of car owners would be willing to rent out their car through a peer-to-peer car sharing platform for a price comparable with rental companies under similar insurance schemes

To this end a questionnaire was elaborated (Annex II) which aimed at identifying if there is a considerable percentage of the general population willing to share their car, at which price point and under which conditions and circumstances they would do so.

The questionnaire was disseminated via online channels (facebook groups, linkedin, direct email to startup ecosystem stakeholders and startup founders), via two targeted workshops within the frame of the OK!Thess[54] pre-incubation program and via JRC's mailing list. This resulted in collecting answers from 254 participants mainly originating from Greece and Italy with a wide age distribution. Out of them 29.1% would be willing to rent out their car at €36, a price competitive to alternative options such as car rentals.

Figure 7. Main findings of the B2C assumptions-validation experiment

[54] http://www.okthess.gr

A more detailed distribution is presented in **Table 15**. The table includes the average number of cars owned and the perception of cost of ownership. The data indicate that participants belonging to the 18-25 age group constitute the most engaged potion of the public with 38.3%, although they own less cars on average and their perception of cost of ownership is lower than other groups. Age groups 26-35 and 36-45 also show high rates of value proposition acceptance exhibiting comparable metrics.

Table 15. Results of the B2C assumptions validation experiment

Age groups	Participants	Would rent	Age grouppercentage	Owned cars	Perception of cost (€)	Average price/day (€)
18-25	60	23	38.3%	1.26	755.00	35
26-35	56	15	26.8%	1.33	1,530.00	30
36-45	91	25	27.5%	1.48	877.00	31
46-55	35	7	20.0%	1.28	1,736.00	58
56+	12	4	33.3%	2	1,813.00	26.6
	254	**74**	**29.1%**		**1,342.20**	**36**

Table 16. Recurring themes B2C experiment

Recurring Themes (concerns in support of opt in)
Full insurance coverage
Driver is trustworthy, driving record known
Returned as rented (cleanliness, tank capacity)
Make profit
Security deposit upfront
Restrictions respected (distance, time)
Simplicity of process (e.g. when damage occurs)

Participation however comes with concerns which were collected as part of responses to an open-ended question and collectively, out of those who would be willing to rent out their car, fall under as set of themes as presented in Table 16. The prevalent themes of concern were:

- The extent to which insurance coverage would be sufficient for the process of participating in peer-to-peer car sharing
- The prior knowledge (evaluation) of a renter's driving behaviour
- The extend in which the process of participating in such a service is automated.

Secondary themes included the state of a car when returned, security deposits and dispute resolution processes. Interestingly enough the same themes were also brought up by participants not willing to rent out their car, perceived as the main blocking factors for participation.

The results overall validated the assumption that at least 20% of car owners would be willing to participate in a peer-to-peer car sharing service, with comparable pricing and insurance coverage to car rental services. Additionally, the online survey collected 66 emails of participants interested in knowing more about the service at a future date, which accounted for 26% of the total of 254 respondents.

4.5. Conceptual architecture

Following the conducted market analysis, the in-depth interviews and all activities aiming to identify a market niche with the lowest possible friction, identifiable and significant growth rate and in-line with the research team expertise and knowledge, a top-level architecture was envisaged that leverages blockchain technology in the peer-to-peer car sharing space.

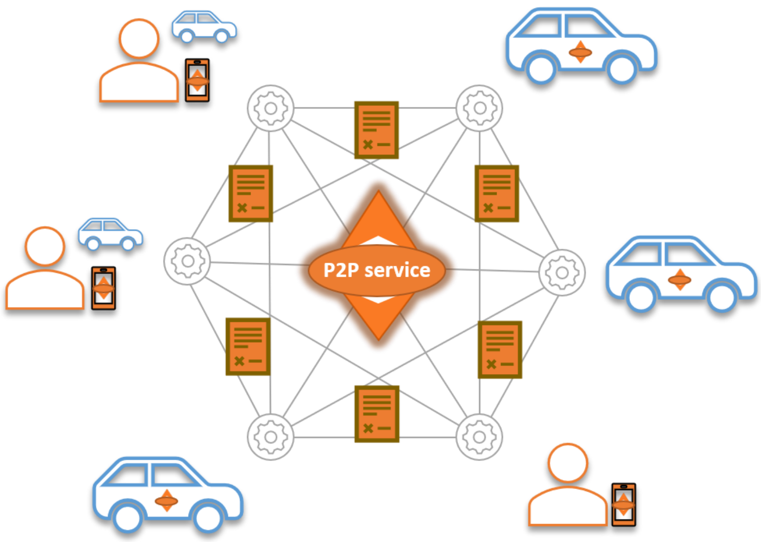


Figure 8 High level concept

The approach was for the architecture to be able to support any peer-to-peer car sharing service, leveraging blockchain technology and the required in-car technology and cloud services. The following figure includes a more detailed layer-based concept of how blockchain technology fits into the overall picture.

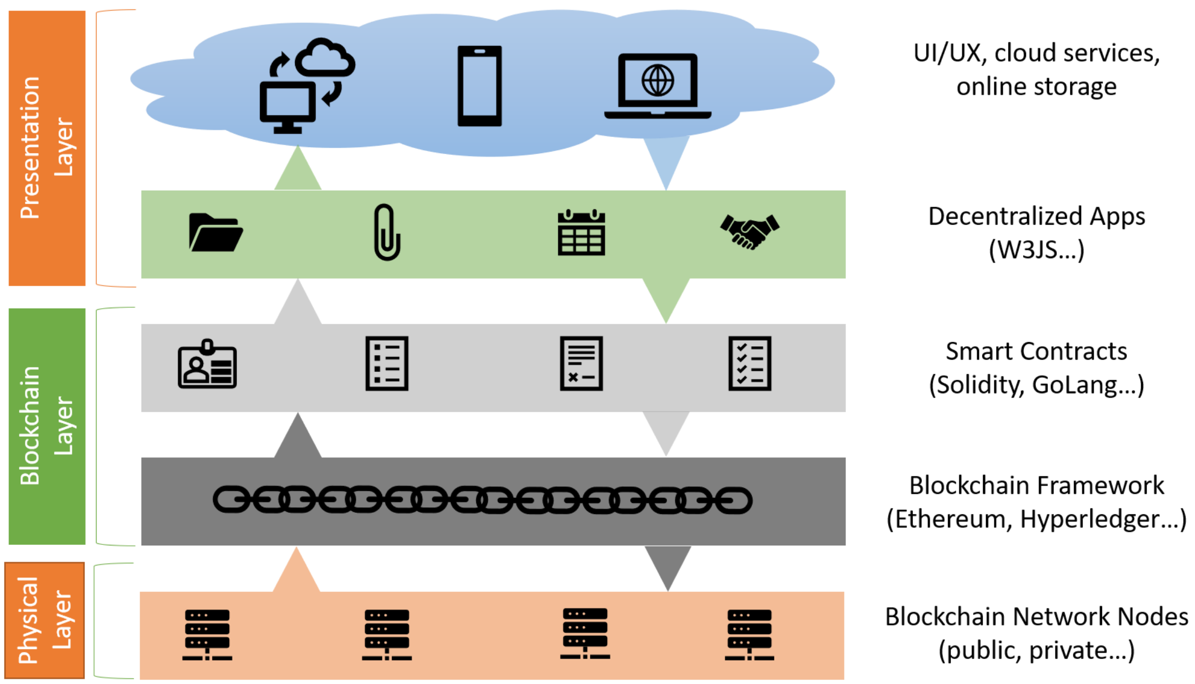


Figure 9 Platform layers

The figure indicates that the physical layer can be implemented under several possible configurations:

- Private network. This implementation indicates that the network would be managed by the company that will bring the product to market.
- Consortium network. The implementation would entail that blockchain nodes would be deployed among participating entities in a permissioned or permission less fashion leading to a higher degree of decentralisation of the architecture.
- Public network. A public network would indicate that anyone would be able to deploy blockchain nodes and thus participate in a permissionless fashion.

The blockchain layer suggests that there are multiple options in terms of which blockchain frameworks can be applied. Ethereum, Hyperledger (Fabric, Sawtooth...), IoTA (Tangle) and others could provide the required functionality provided that the framework chosen can support smart contract creation, increased number of transactions and scale. Smart contracts would be essential in supporting enhanced process coordination in a trust-less and automated manner among disparate participants. Common smart contract programming languages, depending on blockchain framework, are Solidity, GoLang, Python and others.

The presentation layer brings together cloud services in support of the necessary functionality and also integrates the decentralised applications or dApps programmed in W3.js, Web3.py or other relevant programming frameworks. dApps will have their frontend code making API calls to the smart contracts deployed in the blockchain network, thus consolidating process flow across layers.

Considering that the nature of peer-to-peer networks requires an ever increasing number of participants with stratified access rights to the various services it was suggested that a consortium based network would be required. To this end Ethereum was considered as an appropriate framework, including smart contract functionality.

To further support this architecture however an element was missing, one that would support the decentralisation of the network in a manner that would be (a) economically viable for participants and the service, (b) applied by non experts in a plug and play manner and (c) provide value to the network beyond just deploying an extra blockchain node. It was thus suggested that this requirement would be sufficiently addressed by in-car technology. An in-car hardware implementation that could not only support a blockchain node but also provide the "state of the vehicle" information that could further enhance a commercial peer-to-peer service offering. Such information could support real time monitoring of a vehicle, report on geolocation, characterise driver behaviour, offer basic remote management (e.g. lock/unlock) and other information that could augment the service's value proposition to its customers.

In light of the aforementioned considerations the final conceptual architectural framework included:

- **A Blockchain Technology Layer** to include the appropriate distributed ledger technology, supporting smart contracts and decentralised applications
- **A Cloud Services Layer**, whereby the necessary services can be elaborated in support of identity management, transactional automation, efficient information sharing, blockchain network connectivity, process coordination and others
- **An in-Car Technology Layer**, that can provide real-time monitoring of a vehicle's state and basic remote management, whilst at the same time equipped with sufficient processing power and storage capacity to host a blockchain node in support of decentralisation and trust.

The following figure represents the different layers of the conceptual architecture and their indicative functionality.

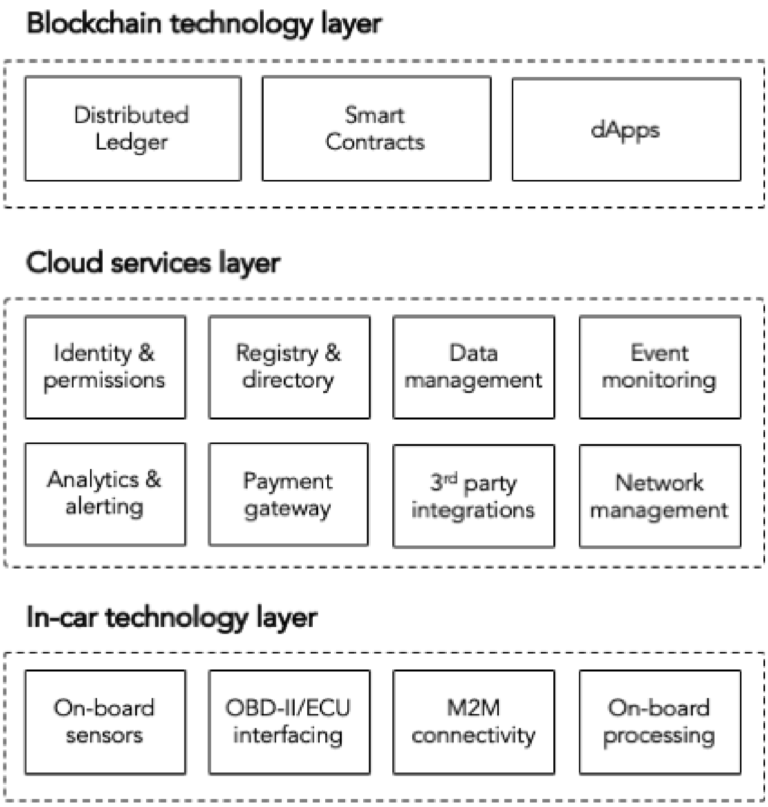


Figure 10 Indicative technology components

5. Demonstrator

The present chapter summarises the activity that took place for the development of a first functional prototype within the project. The prototype was based on the key assumptions introduced in the original project scoping making use of existing JRC tools (the GreenDriving Tool) for linking real time vehicle data monitoring to cost and emissions estimation functions, allowing the deployment of a ride-service sharing platform. There are already several available applications on-line that deal partly with the problem of transport service allocation and optimisation. Most of these applications (a.) rely on centralised web systems that eventually create closed eco-systems, (b.) provide no transparency over the pricing of the activity offered. It is suggested that the application of BC technology can act as an enabler for transport-as-a-service operations and help improve the efficiency of transport services improving both, costs and the environmental footprint.

As described onwards, the main focus of this work was on creating the design the corresponding implementation workflows for connecting different systems involved in the project namely, vehicle to blockchain, blockchain to IT system/database, IT system to blockchain. Consequently, this work lays the foundations for further design and implementation of the necessary basis to support a platform along the lines described in the previous chapters. The main outcomes from include:

- A way for processing and transmitting vehicle OBD data to the JRC web services.
- The development of an RPI based system for data communication between vehicle and the blockchain platform. The implemented RPI system communicates and exchanges information with the JRC's web services (GreenDriving Tool) and the Ethereum BC network.
- Ad-hoc Contributions to the definition of the workflow followed for the demonstrator of the project.
- The smart contracts deployed in the demonstrator and their specifications definition. This included functional activity mapping between disparate systems/clients and provision of implementation solutions when needed.

Table 17. Test code metrics

Language	Files (#)	Blank (lines)	Comment (lines)	Code (lines)
JavaScript	2	110	39	692
Markdown	6	36	0	241
Solidity	1	65	121	166
Bourne Shell	3	21	7	105
Python	3	23	23	101
YAML	1	0	0	49
Dockerfile	4	0	0	22

All relevant software code and respective documentation can be found in https://github.com/MichalisMak/ridechaindemo . The following table summarises the metrics of the test code developed within the project,

Small scale Demonstrator

The small-scale demonstrator developed in the present contract consists of 3 components.

1. The smart contract that acts as the escrow between the 2 parties
2. the car probe that currently is used to upload the car coordinates to the blockchain at set intervals.
3. the GUI that is used for all interactions with the contract

The Contract

This is the bit that runs on the ethereum network containing most of the business logic and acts as the escrow, receiving down-payments and dispensing payments once the ride is resolved. It is a long running contract, owned by the administrator of the system.

The Probe

The probe is an ad-hoc developed hardware system based on raspberry pi equipped with a GPS receiver, an ODB2 interface and an internet connection, that runs its own ethereum node. Every few seconds, the probe will send an event to the blockchain with the new coordinates of the car.

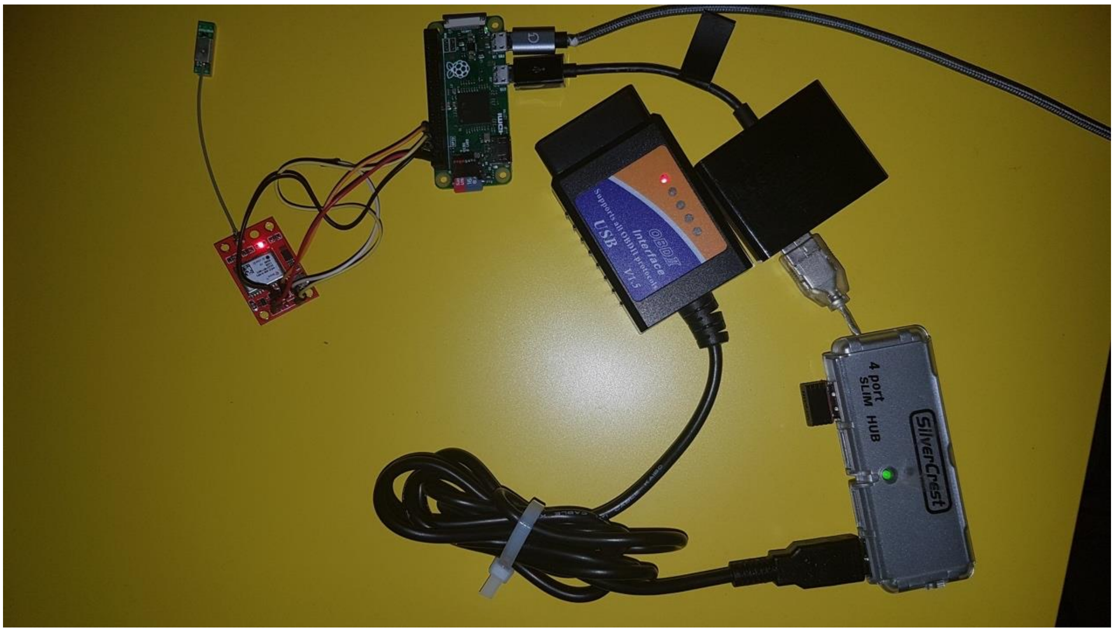


Figure 11. Demonstrator probe. rpi, obd 2 & gps receiver

The GUI

Web3js based GUI, to be used in conjunction with an online wallet (metamask, mist), provides access to the system for both drivers and their prospective clients.

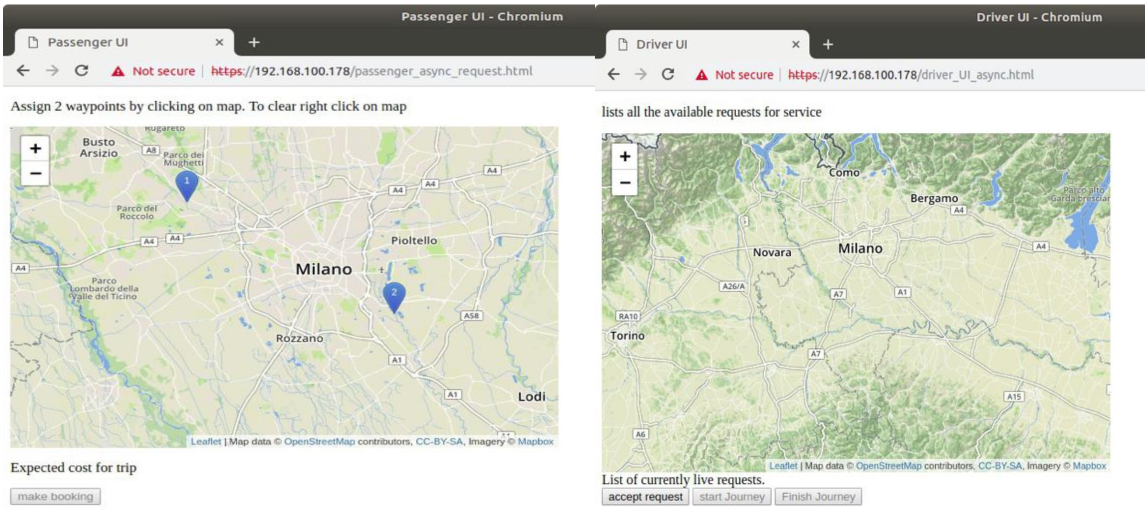


Figure 12. GUI snippets

System Architecture

The system architecture was decided after consultation with the project team and the JRC coordinator. It comprised of the following main elements that are visualised in Figure 13.

1. Passenger selects route on GUI map
2. Passenger application queries Usave for the expected fuel consumption & duration
3. Passenger makes a RequestForService call to the contract, passing the expected cost, fuel consumption and duration as well as coordinates of route. This is a payable call that accepts the full deposit for the ride.
4. When transaction is confirmed a request for service event is emmited.
5. Any driver that is listening for events will get a notification and the ui map will get updated.
6. A driver can accept the service by making an AcceptRequest call to the contract. This is payable function that accepts the full deposit for the ride.
7. The contract once the AcceptRequest transaction is mined will emit an event of the same type.
8. The passenger will then start listening for the UpdateCoordinates events that are constantly emitted by the car probe.
9. The Driver is responsible for starting the journey and informing the contract when the journey ends.
10. When the driver calls FinishJourney the contract pays back his deposit plus the passenger's fee.

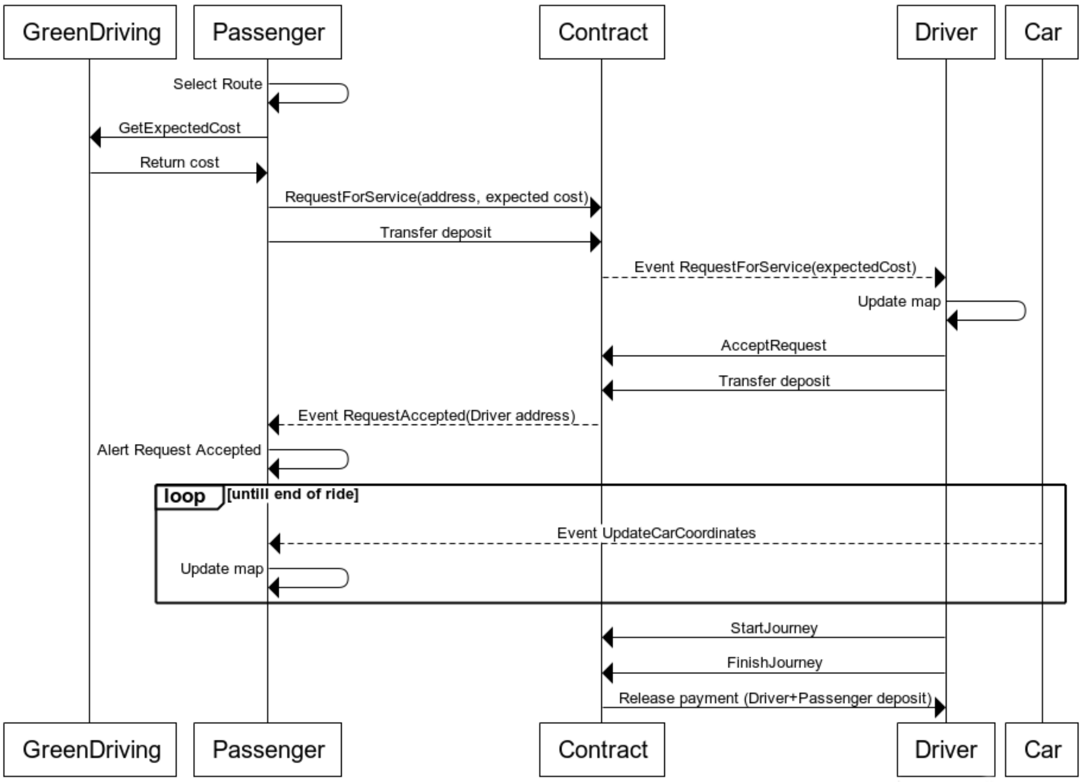


Figure 13. Prototype implementation sequence diagram

Design decisions: Running the beacon on top of a local a node

The beacon program is running on top of a local geth light node. The light node is specially designed for devices with restricted resources both in terms of storage and network. It only downloads the block headers and does do no verifications. In terms of storage only ~2MB of headers are stored and it downloads about 1KB per 2 minutes. Running a node on the onboard device rather than using a standard client-server protocol was decided for reasons of simplicity. The ethereum network has built in redundancy capabilities and we're leveraging that in our situation where reduced or no network connectivity is expected to be quite common. The beacon checks the coordinates every N seconds and raises an event in the ethereum network if they have changed. We chose to emit the coordinates as events as the are the cheapest form of storage on the blockchain at ~8 gas per byte. The other reason for choosing events is that the updates can be pushed to the clients rather than having them constantly querying a node.

Limitations

Currently the contract does not support cancellation or modification of the contract before the ride is finished. Disputing the ride can only be done by a third party that will have to inspect the blocks with the transactions for the specific ride and give a verdict. Currently the system queries the GreenDriving API (GD), to get a cost for the trip. GD returns the expected fuel consumption and trip duration for an average car. The system does not currently allow the driver to modify the parameters for his specific vehicle.

Results

The system was presented at the JRC between the 26th and the 28th of November 2018. After configuring the system and setting up a private ethereum blockchain network we successfully simulated a ride being hailed. 3 of us, 1 acting as the passenger and driver and 2 acting as the car. The main problems encountered during this demonstration was connectivity issues due to the very restrictive wireless network of JRC. The demonstration proved that a blockchain ride sharing/hailing system is viable and the inherent delay in the network due to transaction verification does not make it unworkable. Further information regarding the software documentation and the respective deployment guidelines can be found in the Annex.

Design issues and future development

The system uses events to transmit state changes in the system. One of the issues we noticed with this approach is that often there are delays in the events getting propagated through the nodes or even missed altogether, even on a private ethereum network. We currently don't wait for multiple confirmations to happen before the ride is confirmed to the driver. Once a transaction is mined and an event is raised, the party interested is automatically informed. 6 confirmations per block are the recommended minimum to be secure and ensure the chain has reached consensus and no more reorganisations will happen. There is the possibility of collision where two drivers attempt to get the same ride, simultaneously. It is possible that both transactions are mined but only one of them will get accepted when the chain reaches consensus. The current implementation does not account for that as it would make the system very sluggish and unresponsive. Another factor is that a driver that is willing to get less profit might give higher gas fees in order to get priority in his transaction getting confirmed.

A future development could be to:

- Enable the driver to set the parameters for his car/specific trip (number of people, baggage etc).
- Allow the drivers to send quotes, so the client can decide which one is most affordable. By allowing the client to decide which offer to accept, the aforementioned issues with transaction collisions or gas sacrifice in order to get the ride first are solved, since the competition will be on the actual price of the journey.

6. Concluding remarks-Follow up

Following the extended market analysis and assumption validation process, the research team conducted some basic market validation activities. The first opportunity arose with the MOVE 2019 - Mobility Re-Imagined event that took place in London, UK on the 12th and 13th of February 2019. The overarching concept was to present a hypothetical technology provider for the market, which leverages blockchain technology to facilitate peer-to-peer car sharing services, and to solicit feedback from established stakeholders in the field with regards to their market insights and how they perceive the use of blockchain in the field of shared mobility. To this end, a startup company - to be established with the aim to further explore and develop the outcomes of the present project - was envisaged as a potential spin-off of the Joint Research Centre, Directorate C - Energy, Transport and Climate - Sustainable Transport Unit C.4, called **Innomovo**. The effort included the following four parts:

- A website descriptive of a technology provider in the field of peer-to-peer car sharing space;
- An explainer video included in the website;
- A pitch deck to support the Innomovo positioning;
- A financial analysis of a SaaS business model, fitting a technology solution provider, such as Innomovo.

All four can be found in Annex III-V.

The visit to MOVE 2019, the insights from the event presentations and the subsequent talks with market stakeholders substantiated that blockchain is a good fit only to decentralised applications serving disparate parties, with companies like Turo (P2P car sharing, US) considering its use in the future. One of the most promising interactions was the one with MOBI[55], the Mobility Open Blockchain Initiative. The concept behind innomovo was considered very attractive and in-line with the initiative and thus was invited to take part in the upcoming MOBI Mass Challenge[56].

To further enhance the project's outcomes and in direct correlation with the envisaged architecture, a research is on-going in the field of in-car technologies that support blockchain application scenarios. The preliminary research results revealed several technology patents that identify the need for in-car technology able to convey key information about a vehicle's state, but also to allow a vehicle to take part as a unique entity in the future mobility landscape, where connected and autonomous cars will be able to interact with drivers, services and infrastructures.

Over the last decade several patents and research outcomes have been put forward by individuals, vehicle manufacturers and ICT companies which combine blockchain technology and vehicles. Most are focused on the logging side of the benefits blockchain can offer, others in the cybersecurity issues that will become more prominent with the advent of autonomous and connected vehicles. However, very few refer to the operational side of the equation where vehicles are an entity within the broader future of interconnected services in the mobility sector. Facilitating on-board intelligence with features addressing cybersecurity and access, logging immutability, real time communication, safety and other characteristics are not currently addressed in a satisfactory and holistic manner.

The previous has led the research team to submit a Patent Declaration Form (Annex VI) of a proposed in-car technology that takes into account the following three main aspects:

[55] https://dlt.mobi/

[56] https://dlt.mobi/stage-one-mgc/

- The technical solution should be based on standards and extend them, thus being compatible with all vehicle types and facilitate easier uptake by OEMs in the field;
- The technical solution should foster all the necessary communication ports to interface with a vehicle, on-board sensors, as well as mobile networks for information transfer;
- The technical solution should provide enhanced processing power and storage capacity to be able to host the required software implementations.

The latter was however rejected due to the presence of similar patents granted (dating 2018, while the project was on-going). However, the research team truly believes that the field of application is broad and is confident that potential for patents based on the outcomes of the present activities still exists and should be further explored.

List of figures

List of tables

Annexes

Annex I - Questionnaires

B2B service - Assumption Validation Questionnaire

Question groups per metric

Company profile

- How many vehicles do you own?
- How many vehicles have you rented out last year?
- What percentage of your fleet remains idle depending on the period? What is the expected fluctuation?
- What is the age of the vehicles in your fleet?
- What vehicle categories do you own?
- What is the average rental time?

Car sharing as a company practice

- How often do you practice sub-renting/car sharing?
- How important is car sharing in your line of work?
- Is it an important practise and why?
- Last time you practiced it what was the process you followed? (process, logistics)
- Last time you responded to a sub-rental request what was the process you followed?
- What is the process once a vehicle has been identified as available?
- When you are searching for a vehicle what are the criteria affecting your decision?
- When you are asked for a vehicle what are the criteria affecting your decision?
- How many times were you asked for vehicle over the last year? (availability)
- How many times where you able to comply with the requests? (demand)
- When you could not comply, why was that?
- How many times did you search and request a vehicle over the last year? (demand)
- Of the times you requested for a vehicle how many did you manage to get one? (availability)
- When you couldn’t find one, what was the reason?
- Where there times when you could search for a vehicle and you didn’t and why?
- Where there times you could accomodate a request but you didn’t and why?
- In what way does seasonality affect your need to find a vehicle?

Financial impact of car sharing

- What percentage of your total revenues comes from vehicles sub-rented to other professionals?
- What percentage of your total revenues comes from vehicles sub-rented from other professionals?
- How is your revenue model affected? (percentage of revenue and logistics)
- Could your revenue be increased if demand and supply becomes a more streamlined process?

Problems and room for improvement

- Are there any issues with how this process is facilitated currently?
- Where there any relevant issues in the past?
- Where there any mistakes in the past, which ones are the most common ones?

- What could make this process easier?
- What is the time required, what are the problems associated?

Widening the network as a solution

- How many professionals can you reach as part of your network?
- Would you want you network to become wider than it currently is?
- Under which conditions would you grow your network?
- Do you receive requests from professionals outside your network?

Willingness to try a software solution

- Do you believe a software solution could streamline the process?
- What could a software solution provide to streamline the process?
- Have you searched for a similar software solution in the past?
- Which other software do you use in your line of work?

B2C service - Assumption Validation Questionnaire

New startup loading...and we need your help!

In this brief survey (3 minutes) we would like to investigate how people perceive their relationship with their car. Answering this short survey would really mean the world to us.

*Required fields

Personal Details

Some demographics to help us out

1. How old are you? * (Mark only one.)

18-25
26-35
36-45
46-55
Other:

1. How many members in your family/household? * (Mark only one.)

1
2
3
4
4+

3. What area do you live in? * (Mark only one.)

Urban
Suburban
Rural

4. Which country do you live in? *

Open ended question

Let's talk about cars. We are interested in knowing about your relationship with your car

5. How many cars do you own? * (Mark only one.)

0
1
2
>2

6. How old is (are) your car(s)? (Tick all that apply.)

Car 1 : [less than 5 years] [between 5 and 10 years] [over 10 years]

Car 2 : [less than 5 years] [between 5 and 10 years] [over 10 years]

Car 3 : [less than 5 years] [between 5 and 10 years] [over 10 years]

7. How much do you estimate the annual cost of owning a car (not usage, just ownership)?*

Open ended question

8. How often does your car stay unused for a full day or more? (Mark only one.)

every weekend

more than two days a week

a couple of days a month

a couple of days per year

I always use my car(s)

Other:

9. Have you ever lent your car to someone apart from immediate family members? (Mark only one.)

YES
NO

10. If YES, how often do you do that? (Mark only one.)

a couple of days per year

a couple of days per month

11. Would you be willing to rent out your car to another individual? * (Mark only one.)
YES
NO

12. If YES, under which conditions would you be willing to do so?

Open ended question

13. At which price/day would you be willing to rent out your car?

Open ended question

14. If NO, what makes you hesitate to do so?

Open ended question

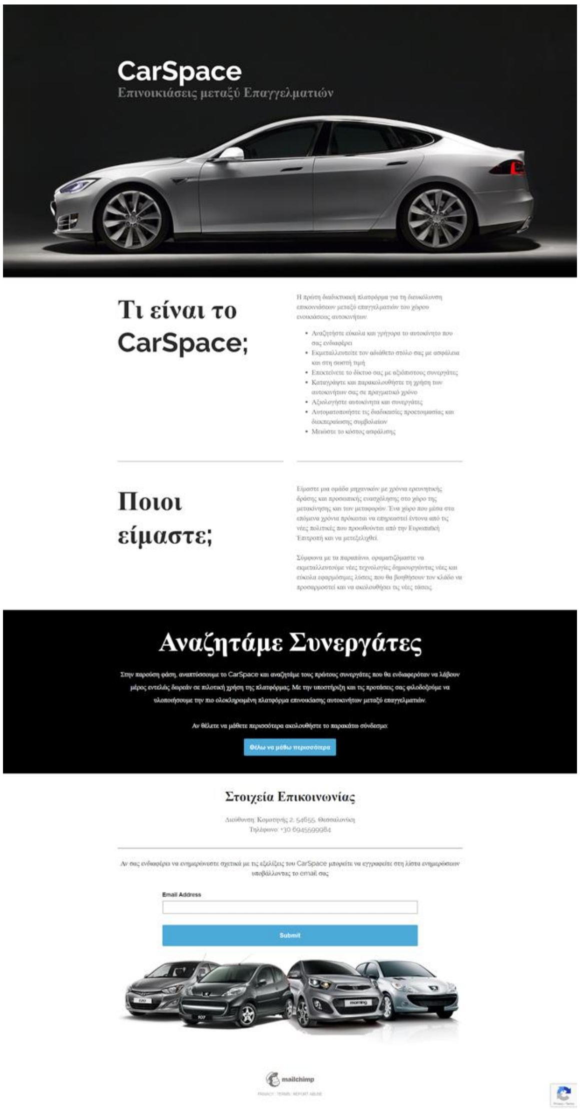
15. Would you like to be informed of our future steps? Type in your email and we will keep in touch

Open ended question

\---

Annex II - Landing pages (IT, GR)

The landing pages created for the purposes of marketing and soliciting feedback from car rental owners are:

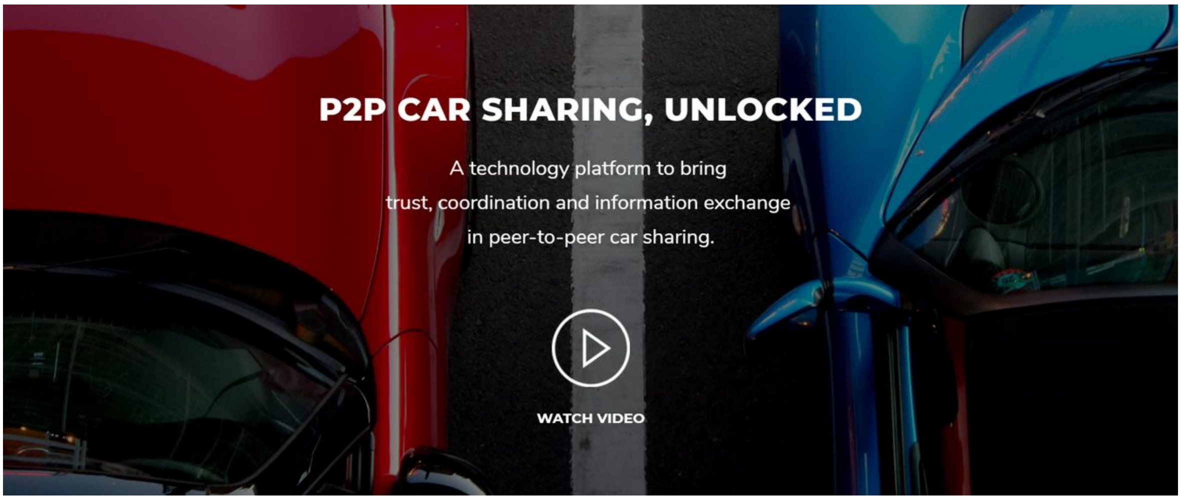


The landing pages above are accessible at the following temporary URLs:

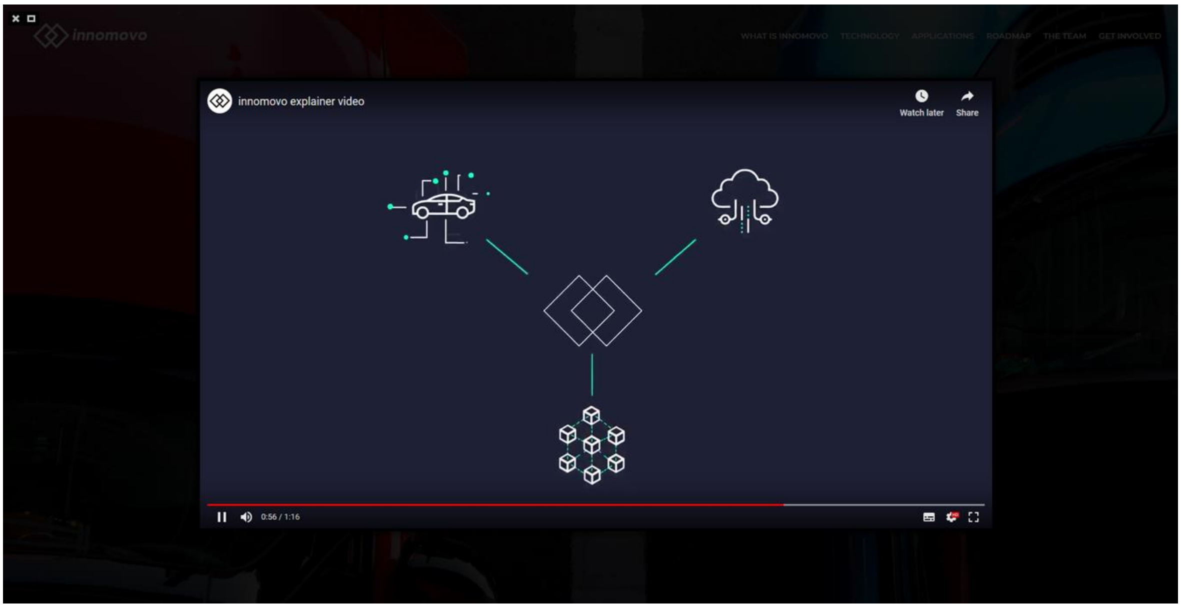
- Greek Website URL: https://mailchi.mp/0372c08e4ee1/carspace-gr
- Italian Website URL: https://mailchi.mp/b0dd86d025a7/carspace-it

Annex III - Innomovo website & explainer video

Innomovo website: https://innomovo.com/

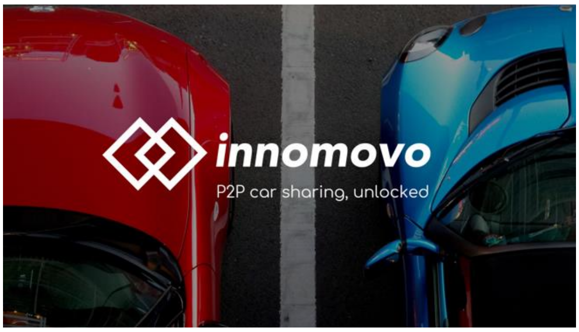


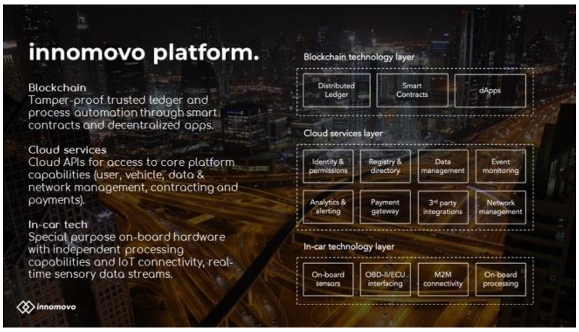
Innomovo explainer video: https://youtu.be/u8vmzGR82Aw

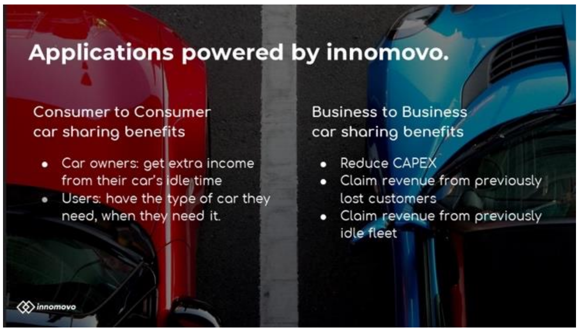


Annex IV - Innomovo pitch deck

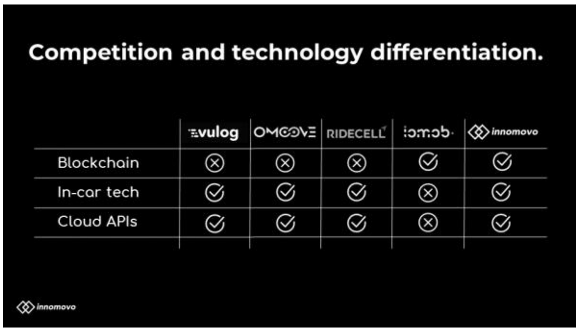
Pitch deck download: https://docs.google.com/presentation/d/1F9Crdync5QROMPdF1aw-cMN8FO2wxFOW4r550Y0NTA4/edit?usp=sharing



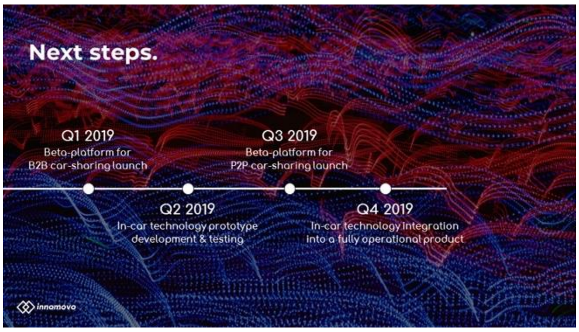




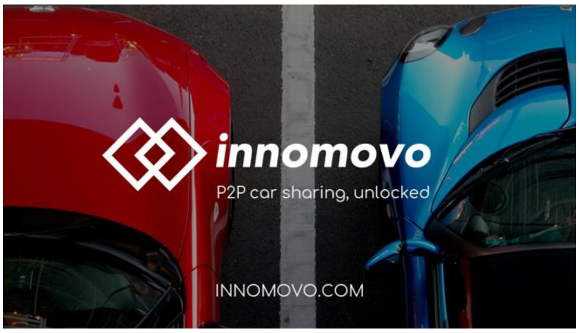

Go-to market.
1. B2B car sharing as beachhead market.
2. Proof of concept with CarSpace.online (GR and IT)
3. Expansion to C2C car sharing networks
Geographical focus
1. Professional "rent to rent" market in South Europe
2. Rest of Europe, starting from major cities
innomovo


Competition and technology differentiation.
vulog
RIDECELL
innomovo
Blockchain
In-car tech
Cloud APIs
innomovo


Progress to date.
Q3 2018
Concept validation & architecture design
Q1 2018
European Commission backed PoC project begins
Q4 2018
Ethereum-based prototype development & testing
innomovo


Next steps.
Q1 2019
Beta-platform for B2B car-sharing launch
Q3 2019
Beta-platform for P2P car-sharing launch
Q2 2019
In-car technology prototype development & testing
Q4 2019
In-car technology integration into a fully operational product
innomovo

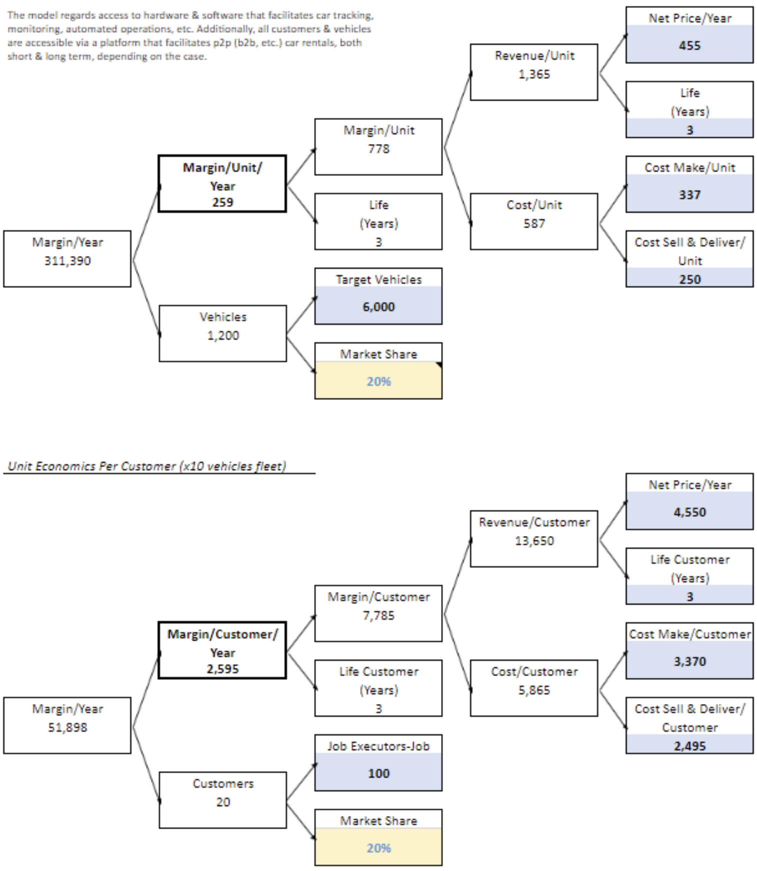

The team.
Georgios Fontaras
Vehicle Technology Expert
PhD in Automotive Engineering, 15 years research in Clean & Efficient Vehicles, Coordinator of the project.
Micholis Makridis
ITS Expert
PhD in Computer Science and Artificial Intelligence, 4 Years research in Transport Modelling, Autonomous Vehicles & Traffic Flow
Vasileios Christoras
ICT Expert
15 years professional experience in software development and project management.
Stefanos Tsiakmakis
Energy & Transport Expert
PhD in Mechanical Engineering, 10 years professional experience in consulting and managing energy related projects.
Nikolaos Tsoniotis
Product Innovation Expert
MEng in Electronics Engineering, 18 years of R&D and entrepreneurial experience, business development advisor.
Dimitrios Kourtesis
Technology Commercialization Expert
PhD in Computer Science, 14 years experience in creating software systems and helping launch new software products.


innomovo
P2P car sharing, unlocked
INNOMOVO.COM

Annex V - Innomovo financial analysis

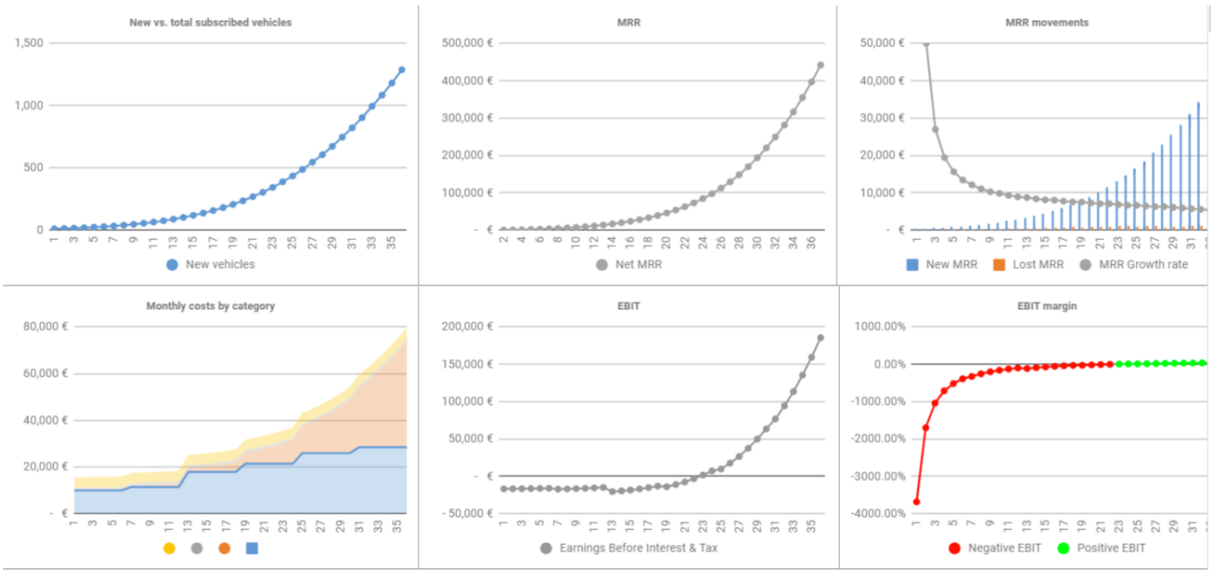
The figures below are excerpted from the financial model that was developed as part of this research.

Basic Unit Economics



Assumptions

Parameter	*Value*	*Unit*
Vehicles	60,000	-
% owned by small fleet owners	10%	-
Target Vehicles	6,000	-
Customers	400	-
% owing small car fleets	25%	-
Target Customers	100	-
Fleet Size	10	-
Hardware Leasing	275 €	/unit/year
Software License	- €	/year
Commissions	5%	-
Average Car Rental Price	30 €	/car/day
Average Insurance Price	10 €	/car/day
Average Days of Car Rentals	90	days/year
Average Car Rentals Value	2,700 €	/car/year
Average Car Rentals Revenue	135 €	/car/year
Average Insurances Value	900 €	/car/year
Average Insurances Revenue	45 €	/car/year
Total Revenues	**455 €**	**/car/year**
	4,550 €	/customer/year
Quantified Value		
Additional Revenue Gained	10 €	/additional car/day
Increased Business	20%	-
Value from Additional Business	180 €	/year
Incurred Damages	500 €	/car/year
Potential Reduction	30%	-
Value from Lower Damages	150 €	/year
Overall Added Value	330 €	/car/year
	3,300 €	/customer/year
Captured Value	*83%*	
Additional Assumptions		
Life Customer	3	years
Cost to Make	3,369.9 €	/customer
Cost to Sell & Deliver	2,495.3 €	/customer



Annex VI – Patentability analysis results

The European Commission (JRC) has asked Brantsandpatents for a patentability opinion on their concept of System and method thereof of on-board diagnostics (OBD) dongle with embedded Blockchain node. The following summarises the scope of our efforts and our conclusions to date.

[undisclosed text]

Concluding, we deem that the outlined concept is novel over the retrieved prior art, and in particular in regard of the closest prior art US '126. The outlined concept differentiates itself from US '126 by the addition of a battery and one or more sensors. However, we are of the opinion that the added features lack an inventive step. Therefore, we deem the concept not to be patentable.

Annex VII Design and user manual of the RPI-based system for transmission of the vehicle OBD data to services.

Quick instructions on how to set up a car gps beacon for ridechain.

The start up sequence is the following:

- A raspbery pi model ZeroW (or any other raspberry pi but zero has the lowest power consumption)
- An 8GB sd card.
- A gps neo 6m module
- Some way to connect the pi to the internet from your car. The assumption is that either a mobile phone or a dedicated device will act as mobile wireless hotspots to provide internet connectivity to the rpi. Alternatively a 3g/4g modem shield could be added but this is beyond the scope of this document.

Setting up the software

OS setup

Steps 3-5 assume that this is a headless installation via network. Alternatively an hdmi monitor & usb keyboard/mouse can be connected to the pi.

1. Download raspbian lite[57] and install it on the card by using etcher[58] and following the instructions on etcher site. (the easiest option and works in all major OSes)
2. Enable ssh by opening the boot folder on the sd card and create an empty file named ssh. (can also be ssh.txt)
3. Setup the wireless network by creating a file in /boot folder named wpa_supplicant.conf and follow this template :

```
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
country=US
update_config=1

network={
    ssid="My Wifi"
    psk="mypassword"
    key_mgmt=WPA-PSK
}
```

where ssid, psk are replaced with the setting of your wifi router device.

4. Boot the rpi. If all went well it should connect to the network. Contact your network admin in order to get the new ip of the pi.
5. Log in to the pi via ssh, using account pi with default password raspberry.
6. Expand the storage using $ sudo raspi-config and choose 7.Advanced options -> Expand storage

57 https://downloads.raspberrypi.org/raspbian_lite_latest
58 https://etcher.io/

7. Stop the serial console from using the uart. $ sudo raspi-config choose 5.Interfacing options -> P6 serial-> No to console yes to serial. Rebboot and see if device files: /dev/serial or /dev/`ttyAMA0` exist.

GPS daemons & libraries

1. Install gpsd & relevant clients: $ sudo apt install gpsd gpsd-clients
2. run the following command: sudo sed -i -e 's/DEVICES=\"\"/DEVICES=\"\/dev\/ttyAMA0\"/' /etc/default/gpsd && sudo systemctl enable gpsd and reboot.
3. Install python 3.6 as it's needed by pyweb3:
   - Install dependencies first, $ sudo apt-get update && sudo apt-get install -y make build-essential libssl-dev zlib1g-dev libbz2-dev libreadline-dev libsqlite3-dev wget curl llvm libncurses5-dev libncursesw5-dev openssl bzip2 git
   - Get pyenv installer $ curl -L https://raw.githubusercontent.com/yyuu/pyenv-installer/master/bin/pyenv-installer | bash
   - Add & activate environment: $ echo 'export PATH="~/.pyenv/bin:$PATH"' >> ~/.bashrc; echo '$eval "$(pyenv init -)"' >> ~/.bashrc; echo 'eval "$(pyenv virtualenv-init -)"' >> ~/.bashrc; source ~/.bashrc
4. install web3 python extensions: pip install web3
5. install python gps library pip install gps3
6. expand virtual memory:
   - sudo nano /etc/dphys-swapfile
   - set CONF_SWAPSISE=1024
   - sudo /etc/init.d/dphys-swapfile restart

Ethereum for raspi

1. Download geth for arm[59]
2. Untar: tar xvf geth-linux-arm6-1.8.16-477eb093.tar.gz
3. Create a new account: geth password new
4. Copy over the genesys file (can be found on the webnode server) & init geth: *geth init genesis.json
5. Start the geth client: *geth --datadir /opt/geth/data --networkid 53453 --rpc --rpcapi "eth,personal,web3" --bootnodes {bootnode enode}

Setting up the gps receiver.

Connect the power&ground, RX/TX of receiver go to 14/15 gpio (on pi zero these are pins 8&10)

The beacon program.

How to start the beacon:

`python beacon.py --car_address '0xdbe191a206ec3ab84f773bea04f933bf8c2cb381' --contract_address '0xabd50a02fc9c0ca6fdbefd9baa71724e30109fe1' --log_file=/home/pi/gps.log` For help: `python beacon.py --help`

[59]https://gethstore.blob.core.windows.net/builds/geth-linux-arm6-1.8.16-477eb093.tar.gz

UI Node image

This node serves the GUI content for the driver & customer. The docker image produced here spins up an apache web server, with self-signed ssl setup. (Obviously since the keys are published here this is very insecure and new ones will need to be generated before) The html files found in this folder will happily play with any other https server in the market.

Prerequisites

You'll need to have Docker installed. For Ubuntu installation:

```
sudo apt install docker-ce
```

(optional) Generate the self signed keys

```
$ openssl req -x509 -nodes -days 365 -newkey rsa:2048 -keyout server.key -out server.crt

Generating a 2048 bit RSA private key

..+++

...........+++

writing new private key to 'server.key'

-----

You are about to be asked to enter information that will be incorporated

into your certificate request.

What you are about to enter is what is called a Distinguished Name or a DN.

There are quite a few fields but you can leave some blank

For some fields there will be a default value,

If you enter '.', the field will be left blank.

-----

Country Name (2 letter code) [AU]:IT

State or Province Name (full name) [Some-State]:Lombardia

Locality Name (eg, city) []:Ispra

Organization Name (eg, company) [Internet Widgits Pty Ltd]:JRC

Organizational Unit Name (eg, section) []:

Common Name (e.g. server FQDN or YOUR name) []:ridechain.jrc.eu

Email Address []:your_email@jrc.eu
```

copy server.key & server.crt to the same directory as your docker file is.

```
cp server.key server.crt UI_node/
```

Create the image

```
$ cd  UI_node
$ sudo docker build -t uinode .
```

Run the container

```
sudo docker run -p 443:443 -v $PWD/content:/usr/local/apache2/htdocs/ uinode
```

The container should now be accessible on https://yourhost/

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JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

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