CROWD4ROADS

CROWD sensing and ride sharing FOR ROAD Sustainability

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D2.2 — Representative Scenarios and Use Cases

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Abstract: This report identifies and assesses a set of representative scenarios and use cases to be used in the development of the CROWD4ROADS project. The scenarios and users identified will be used to construct and tailor strategies in which the systems part of CROWD4ROADS will be aimed towards, in order to achieve maximum engagement.

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Executive summary

This document corresponds to Deliverable 2.2 of the CROWD4ROADS project. This report documents the user scenarios and use cases that have been informed through a needs assessment methodology. This assessment has taken into account the background literature and data available concerning the current trends of users who engage with the eco-efficient services; ride-sharing and road-sensing. Following this, the socio-economic analysis carried out by BucksADV in D2.1 Socio-Economic Analysis and Sustainability Threat, has been used to further inform the scenarios and use cases that should be applied for the use of the CROWD4ROADS project.

Presented in this report are three use cases that have been chosen, the reasoning and research that supports their use and the use cases that will support the development approach of implementing these user preferences within the CROWD4ROADS technologies.

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1. Preface

In this report the activities of the CROWDS4ROADS project as pertaining Task 2.2, assessing the needs, research literature and prospective scenarios as pertaining road state, carpooling and road sensing, so as to ensure addressing the issue of sustainable transportation from an innovative, holistic and impactful perspective. This assessment was aimed at defining a number of sound and adaptable scenarios, user groups and Use Cases to be implemented in subsequent Work Packages.

The report begins with presenting an assessment of the needs and the situation as pertaining carpooling, road sensing and their impact on road maintenance on a European level, exploring the opportunities and the voids in current research literature, policy implementations and industry practice, so as to ensure the maximum impact for change, while highlighting the difficulties of navigating such a complex and diverse field, and the variety of European transportation issues and contexts.

Based on the analysis, representative scenarios and use cases have been defined to drive the definition of deployment of pilots and test beds. Scenarios have been classified based on their scope, on their relevance for socio-economic development, on the types and number of public and private stakeholders involved, and on the strategies and level of commitment required both on their part on from the investigators. Use Cases will be distinguished based on the motivations of individuals and on the subsequent avenues for improving the degree of adoption of both ride sharing and crowd sensing as integrated in the CROWDS4ROADS ecosystem.

The hereby discussed Use Cases will in turn inform the definition of possible test beds and the design and implementation of pilots for validation, demonstration and assessment.

2. Needs assessment

This chapter outlines the work taken to assess and review the current state of the eco-efficient services; ride-sharing and road-sensing, that are to be the focus of the CROWDS4ROADS project. These considerations are drawn from within the network of transport and mobility services literature and data sets, to form an analysis of how these services are marketed, used and perceived by various user groups within the general public. The needs assessment will be used to identify gaps in the adoption of these services amongst different user types and will ultimately be used to inform a series of scenarios of key target user groups for the purpose of testing pilot solutions using CROWDS4ROADS technologies.

2.1. Statement of purpose

The project combines and enhances existing trip sharing and crowd sensing initiatives to harness collective intelligence, contributing to the solution of two well-known sustainability issues of road passenger transport: namely, low car occupancy rate and delayed road maintenance.

Roads are often the single largest publicly owned national asset. The road infrastructure and its conditions provide a fundamental foundation to the performance of all national economies, delivering a wide range of economic and social benefits. Road transport accounts an average of 4% of GDP by itself, while the overall contribution of the road infrastructure to national economies lies between 10% and 20%. In 2012, 92.5% of inland passenger transport [EUST_PTS14] and 75.1% of inland freight transport [EUST_FTS14] in EU-28 countries went on roads. Passenger cars account for 73.7% of total intra-EU passenger transport [EC12].

Road maintenance is essential for safety, wellbeing, economy, and environment. The main principle driving the need for maintenance is that spending money now avoids higher costs in the future. According to the World Road Association, low income countries, which under invest, spend 50% more on the road network (per kilometer) than higher income countries [WRA14]. Moreover, the World Bank has shown that delayed road maintenance increases the total vehicle operating cost by two to three times the savings in maintenance. Inadequate maintenance places undue financial burden on future generation, impairing sustainability. SITEB has provided a careful estimate of the total value of the upper structure of the Italian roads, coming to the astonishing figure of 1,250 Billion Euros [SITEB12]. Road decay can be stopped only with preservation and well planned maintenance actions; this is the only way to preserve such an immense asset.

The same report shows how the delay in maintenance impacts maintenance costs, providing the economic motivation for the adoption of maintenance policies based on real-time data and sound models. On its turn, the need for up-to-date comprehensive data prompts for the development of non-intrusive inspection and monitoring techniques, causing no impairment to transport flows [ERTRAC13]. Regular monitoring and reporting is essential for maintenance programming. On the other hand, road traffic has a non-negligible environmental impact in terms of noise, pollution, and energy. Passenger cars alone account for 12% of CO_2 emissions in EU [EC15]. According to the Europe Environment Agency, car occupancy rates decrease over time due to the drop in household size and to the increase in car ownership [EEA11]. The average occupancy rate is well below 2 passengers per car, and it approaches 1.1 for commuting. Car sharing and car-pooling initiatives [CIVITAS15] are essential, together with the adoption of less car-dependent lifestyles, to invert the car occupancy trend and reduce traffic congestion.

Collective awareness is essential both to induce and to accept the adoption of adequate policies. End-user engagement provides both a direct effect, allowing the community to benefit from the service provided by individuals, and an indirect effect, being for sure the most effective way of raising awareness.

The CROWD4ROADS project aims at engaging drivers and passengers in the development and adoption of more sustainable car usage habits and road maintenance policies.

10 million users [BlaBlaCar], and SmartRoadSense, a crowd sensing system which exploits the accelerometers of car-mounted smartphones as non-intrusive sensors of road surface quality. The network effect which is inherent in both the initiatives (together with their innovative nature and their technology readiness) is expected to create the conditions to make large-scale real-world pilots capable of providing a sizeable and scalable impact. At the same time, the development of an integrated platform poses challenging issues in terms of scalability and usage models that will be addressed within the project.

2.2. Situation

Transportation lies at the core of society, providing safe and easy solutions to individuals and businesses to connect actions and interactions that would otherwise be inaccessible (Jones, Lucas 2012, Forman 2003). Accessibility is a driving force of economy, employing transportation as a key driver, creating development objectives and utilising mobility of human and material resources to distribute population, industry and income efficiently (Queiroz, Gautam 1992). The infrastructure of road transportation in particular plays an important role in the global economic growth and activity, providing easy access to health and education, social benefits and offers connecting pathways for commercial ventures (Queiroz, Gautam 1992). Road transport accounts for on average, 4% of GDP by itself, whilst the overall contribution of the road infrastructure to national economies lies between 10% and 20%. In 2012, 92.5% of inland passenger transport (Eurostat) and 75.1% of inland freight transport (Eurostat 2014) in the EU, 28 countries operated using a road network. For OECD Europe, a 1% increase in GDP increased the use of road transport to 1.74% and 1.40% in private car traffic (Nijkamp 1994). In total, passenger cars account for 73.7% of total intra-EU passenger transport (European Commission 2014), which indicates a strong public sector usage and dependence on the international network of road systems to pursue daily activities.

With greater accessibility and improved transportation services, a global increase has followed in the demand for production services, which has consequently seen the rise of national and international consumption of resources (Meijkamp 1998). Consumption practices, alongside substantial public usage of the road systems in the EU, has led to concerns of the impact that road transportation has had, and will lead to, on the surrounding ecology and its effects on the environment. Current trends and predicted growth in traffic and road use have been estimated globally as an unsustainable venture, leading to an increased urgency of developing coordinated approaches to sustainable travel policies for preservation of the environment, business, health and social mobility for future generations (Goodwin 1999). The EU's Sustainable Mobility, policy Measures and Assessment (SUMMA) project addressed these issues by evaluating sustainable transport proposals, synthesising the notion of sustainability-as-process and sustainability-as-end-point, as new paradigms. SUMMA built on the EU's 2001 definition, proposing ‘outcomes of interest’ and relevant indicators relating to the economy such as; accessibility, productivity, costs, society, affordability, equity and environment concerns such as resource use, pollution and noise (Rahman, Van Grol 2005, Goldman, Gorham 2006). A white paper issued by the British government on sustainable travel strategies, discussed these needs further and proposed working incentives to help bring about public behavior change to harmonize with government policy, the reduction of unnecessary road travel (DETR 1998).

Amongst these policies, two have been identified as fundamental in moving forwards, towards establishing sustainable road travel; a soft policy of car sharing and a physical infrastructure strategy aimed at developing better maintenance and management of road systems (Santos, Behrendt et al. 2010). Described as part of the move to develop 'eco-efficient services' (Katzev 2003), car sharing and trip sharing strategies, attempt to change consumer behaviors in consumption practices, by offering less environmentally damaging travel options through the promotion of less traffic. Car/trip sharing has been linked to developing positive behavior change concerning reduced travel activities of an individual, leading to environmental benefits such as lower carbon emissions (Millard-Ball 2005a). Similarly, road maintenance and management provides benefits to improving access, comfort, speed and safety and in turn means lower vehicle-operating costs, providing relief to not only the occupants of the car but less emissions are produced overall in to the environment (Burningham, Stankevich 2005). For these benefits to be sustained however, a well-planned program of maintenance strategies must be implemented and supported in order to avoid potential loss of economic and social development opportunities (Burningham, Stankevich 2005).

2.3. Goals of assessment review

The challenge is to harness the collaborative power of ICT networks (networks of people, of knowledge, of sensors) to create collective and individual awareness about the multiple sustainability threats which our society is facing nowadays at social, environmental and political levels. The resulting collective intelligence will lead to better informed decision-making processes and empower citizens, through participation and interaction, to adopt more sustainable individual and collective behaviors and lifestyles. The challenge includes the deployment at larger scales of digital social platforms for multi-disciplinary groups developing innovative solutions to societal challenges.

2.4. Literature & background review

This section provides a review and evaluation of the current research, data and policies in place that support car sharing and road sensing theories as a practice. Current strategies are analyzed and discussed for future application to help create and inform development strategies and Gamification systems to aid public engagement to car sharing (BlaBlaCar) and road sensing technologies (SmartRoadSense) for the project CROWD4ROADS.

2.4.1. Car Sharing

Car sharing and trip sharing strategies are used to promote public consumption behaviour change and are concepts labelled as eco-efficient services. Eco-efficient services are defined as:

'All kinds of commercial market offer aimed at fulfilling customer needs by selling the utilization of a product (system) instead of providing just the hardware for these needs. Eco-efficient services are basically (intangible) services, related to any kind of hardware, of which some of the property rights are kept by the supplier.' (Meijkamp 1998)

Car sharing is one example of an innovative eco-efficient service that offers and promotes adopting the use of rental cars in daily life instead of owning a private vehicle for travel-based needs. This paradigm promotes a personal lifestyle shift for the car owner, from private vehicle ownership to a more environmentally friendly, service use option (Prettenthaler, Steininger 1999). A car sharing system is supported by a car-sharing organisation (CSO's); usually non-profit organisations that collectively own a fleet of cars, a car station/park and normally operates within environmentally sensitive areas (Prettenthaler, Steininger 1999, Huwer 2004). Subscription to a CSO requires a joining deposit (usually refundable) and then a monthly subscription fee. Drivers can book short-term access to a vehicle that matches the driver's travel requirements (pending availability of the vehicle), 24 hours a day, 7 days a week. Drivers are responsible for collecting and dropping off a vehicle themselves and are charged based on two components; hours used and kilometres/miles driven each month (Huwer 2004). CSO's operate at both a local and national level, providing coverage for drivers across a widespread area and thus allowing travel further afield whilst operating within the CSO system (Firnkorn, Müller 2011).

CSO's have increased in popularity and spread across Europe resulting in a substantial growth of public acceptance and adoption. Presented below in Table 1 is a breakdown of CSO services, users and cars offered by 14 supporting countries across the EU (Loose 2010) as reported in a European survey conducted in 2010.

TABLE 1. CSO and User Average per EU Country (Loose 2010).

EU Country	CSO	Cars Available	CSO Users
Austria	Austria Denzeldrive. (NW), Mobility, Denzel Mobility CarSharing GmbH	169	No data available
Belgium	Optimobil Belgium, Taxistop, Cambio, NMBS-Holding	248	6,932
Denmark	Hertz Delebiler, Aarhus Delebilklub, Danske Delebiler	225	5,000
Finland	City Car Club	38	2,232
France	Caisse Commune, Mobizen, Okigo, France Autopartage. (+6)	700	13,000
Germany	110 providers across Germany	3,900	137,000
Great Britain	Streetcar, City Car Club, Zipcar, Connect by Hertz	1,459	64,000
Ireland	GoCar	8	63
Italy	Unique	498	15,850
The Netherlands	Greenwheels, Wheels 4 All	1,832	27,000
Portugal	Carristur	12	100
Spain	Catalunya Carsharing SA	127	2,504
Sweden	45+ providers across Sweden	492+	14,889
Switzerland	Autoteilet Cooperative, Sharecom Cooperative, Mobility Cooperative	2,200	84,500

Based on findings presented in Table 1, Switzerland has shown the greatest increase in user adoption of car sharing services versus country population within the studies scope. Overall, the data indicates that there is an obvious and growing market for car sharing services across the EU, however, it is evident that more could be done to increase the adoption rate. Identifying user perceptions, issues, concerns and behaviors of car sharing systems, could go some way to support future adoption strategies for encouraging individuals and businesses to engage with these eco-efficient policies.

A significant factor which has had an impact on the success of increasing acceptance of car sharing amongst the general population, has been the move to adopt more specific and well-developed technologies to aid users in engaging with CSO systems. In earlier trials of car sharing, users were fully responsible for inputting their own data and recording their monthly usage via a traditional paper based system (Loose 2010). This method however, was largely considered overly convoluted by early adopters, resulting in negative experiences reported whilst employing car sharing services (Shaheen, Sperling et al. 2001). Since this revelation, considerable efforts have been made to improve system procedures that record personal and usage data, with support from intelligent transportation system technologies (ITS) to aid management of these systems (Millard-Ball 2005b). Components of ITS technologies that are now commonly established in CSO systems as described by Millard et al (Millard-Ball 2005a) include:

- **Reservation Management Systems:** Car reservations can be easily made, altered or cancelled via access to call centres, service staff, automated telephone services or web services.
- **Member Databases:** Containing user information, preferences and individual data concerning travel habits/ other desirable information relating to user travel behaviours.
- **Fleet and Parking Systems:** Manages fleet/vehicle data including types, availability and locations.
- **On-Board Systems:** Handles functions such as access, GPS tracking, user registration and records usage times and mileage.
- **Other Components:** Can refer to a range other tracking systems such as; invoicing, tariff management, commercial and performance management and many others.

Whilst there is an obvious shift into creating and supporting better technologies that first engage and then sustain user interest in adopting the car sharing travel ethos, it has been recorded that there is an absence of homogeny of technologies available across car sharing services with little evidence of standardization (Shaheen, Meyn et al. 2003) (Millard-Ball 2005a). In order to promote ease of use and consistency for users engaging in CSO services, a move towards adopting standard technologies across all services could see an increase in user adoption, approval and satisfaction.

A look into current market research on users of car sharing services, identifies distinct groups of customers who share similar characteristics. A study taken to identify user types of CSO's in the United States found that the majority of users of CSO services were Caucasian, highly educated and in their late 30's (de Luca, Di Pace 2014). In addition, research conducted by Burkhardt and Millard-Ball (Burkhardt, Millard-Ball 2006) identifies typical personality types of CSO users which were found to fall into the following five categories: social activists, environmentalists, innovators, economizers and practical travelers. Understanding just who are the typical user demographics that are attracted to car sharing services, can help inform how organizations connect to, attract and broaden their existing customer base by identifying user gaps, potential new customers/groups and new methods for expanding and advancing CSO services to attract a wider audience.

2.4.2. Ride Sharing

Ride sharing also known as carpooling or lift-sharing, is an eco-efficient service that promotes a similar philosophy to CSO systems, that strive to develop positive behavior change in order to obtain sustainable travel. The function of ride sharing and ride-share systems, is to primarily connect and match together travelers with similar travel needs such as destination and schedule, in order to reduce the number of single driver vehicles on the road (Agatz, Erera et al. 2010). Ride sharing operates by employing effective use of a driver's empty car seats, offering opportunities to split the costs, effort and efficiency of travel to and from pre-specified designations. Based on the occupation records of private vehicle usage; 1.2 to 1.4 persons on average per car, compared to occupancy records for carpooling vehicles at 2.5 persons on average per car, indicate that ride sharing could be an effective measure to reduce the number of vehicles for personal travel (Ben-Akiva, Atherton 1977). Following this, there is clear evidence to support the impact possibility that ride sharing could have on reducing travel emissions, congestion, fuel consumption, costs and vehicle kilometers traveled (VKT) for working towards a more sustainable travel system for the future (Caulfield 2009). However, unlike CSO services, ride sharing presents a number of psychological, physical and technological barriers that deter a wide-spread adoption of ride sharing as standard travel behavior.

Technical Barriers

Effective and efficient technologies that match drivers and riders using real-time access has been identified as a necessary component for creating successful user engagement with ride-share systems (Agatz, Erera et al. 2010). In order to compete with private car usage, Agatz et al., (Agatz, Erera et al. 2010) propose that ride sharing must offer an immediate access to door-to-door transportation to be seen as a viable option. Whilst ride-sharing is not a new concept, a new configuration of the old system has emerged. Labelled as 'dynamic ride-sharing', the new system utilizes technological advancements for providing instant and attainable access to users, providing an automatic ride-matching system for members at very short notice (Amey 2010). With dynamic ride sharing, commercial systems available via mobile apps or web-based access are used for managing ride-sharing information, allowing users instant access to post and search for relevant trips of interest (Gidófalvi, Herenyi et al. 2008).

Within these systems there is often provided a series of options that allow members to provide user ratings and feedback based on the experiences of the trip (Assael 2006). This level of social networking, provides both a motivator for ride-sharing drivers to create pleasant experiences for their passengers, whilst also creating a community of trusting members due to easily viewable driver/passenger recommendations and ratings. Most systems even support user profiling for both drivers and passengers, that can act as indicators for matching up preferences such as personality types, interests, music likes, smoking habits and preferred conversation levels (talkative, quiet etc.). Creating greater public access to user data and personal information via social networking accounts, has attempted to address the barriers of safety and social awkwardness of sharing space with strangers, a main factor of user resistance to ride sharing (Van Lange, Vugt et al. 1998). It is therefore reasoned, that to increase adoption rates of ride sharing schemes, technologies and management systems must invest heavily in creating social networks and varied incentives to encourage sharing of personal information, and leaving feedback/ratings to inform other members of their experiences.

Psychological & Physical Barriers

Research into public attitudes and opinions concerning ride-sharing schemes indicate that there can be several barriers including; beliefs, negative pre-dispositions towards an object and intention (Horowitz, Sheth). Additionally, there have been a number of empirical studies that show there are physical barriers such as; travel time, cost, convenience, auto-availability and socio-economic/household characteristics, that influence these beliefs and intentions (Hwang, Giuliano 1990). Attitudinal studies conducted by Margolin and Misch (Margolin, Misch et al. 1978) revealed that subjective factors such as; interpersonal and social connection to unfamiliar persons, expectations of social protocols, perceptions of lost independence and overall status as a passenger, are more of a factor in the consideration of using ride sharing than cost or convenience (Horowitz, Sheth). A study into commuter attitudes and behavior by Glazer and Curry (Glazer, Curry 1987) indicated that commuters were unlikely to adopt ride sharing as they valued their freedom of being alone whilst driving. These findings can be linked to the psychological barriers that make up general distrust and perceived energy required to develop connections to unfamiliar people. Another study into travel inclinations of commuters, found that only a minority of people would feel comfortable and willing to carpool with strangers. Given the option they were more likely to carpool with family or friends (Flannelly, McLEOD JR et al. 1990). The trust/unfamiliarity barrier therefore appears to be one of the biggest psychological factors that discourage individuals from using ride sharing as their main source of travel.

In order to encourage new users into adopting ride sharing, these psychological barriers must be addressed on a very fundamental level and be visually accessible and communicated to potential new users. As previously discussed, travel management systems that have adopted a social networking element of their structure, go some way to help build levels of trust and the feeling of a community surrounding ride-sharing schemes. However, more effort needs to be applied to change existing beliefs up front for gathering initial interest and engagement from a wide range of demographic groups.

Demographic of ride sharing users

In order to further understand and develop strategies to encourage new user groups engagement, it is vital to understand the characteristics of the current adopters of ride sharing services. Data gathered from two main US ride-share services in 2014; Uber and Lyft, identified the following information concerning the average users of their services (Rayle, Shaheen et al. 2014).

Typical users of these ride share services have been shown to fall mainly into the 25-34 age category (57%), with male users making up 60% of the rideshare passenger population. Users have generally received further education past college with 80% of passengers holding a Bachelor’s Degree or higher. Another notable characteristic of typical users, is that 56% reported a household income of $71,000 or higher and a further 40% of all user's household income rose to $100,000 or more. The top 10 destinations for using these ride sharing services were recorded as follows:

1. Home (residential addresses)
2. Workplaces
3. Tourist Destinations
4. Restaurant & Food
5. Bars
6. Airports
7. Retail Stores
8. Fitness Clubs
9. Doctors/Hospital
10. Bus & Transit Stations

It should be noted that Uber provides a premium service with access to executive cars, which may indicate higher user household incomes recorded.

A study to identify ride-share demographics across Europe conducted by Delhomme & Gheorghiu (Delhomme, Gheorghiu 2016), attempted to define some characteristics of ride share users travelling across EU countries. Within their study, they identified six hundred and thirty-four participants who regularly carpooled as drivers and/or as passengers. Among these, 72.2% said they carpooled for work/school trips, 50.9% for children's trips, 86.1% for personal leisure, and 86.5% for shopping. Other significant data from this study found that carpoolers were more likely to younger and have more children than non-carpoolers. Middle aged participants (age 35-49) were more likely to be female and were three times more likely to use carpooling than any other user group. This could be a factor of shared household carpooling, in which other family members/children add to travel needs.

Other considerations of demographic data concern gender tendencies of travel behaviors. Across Europe, travel based demographic data indicates that in low-car households, men are much more likely to be the primary driver. In Germany, a similar study found that men were also more likely to use cars than women (Delbosc, Currie 2012). This disparity however, is smaller amongst households with children, younger households and where women work for longer periods of time. As documented by Jones and Lucas (Jones, Lucas 2012), 19% of women in the UK who are part of car-owning households, are nearly twice as likely to be non-drivers compared to 10% of men. This paradigm however is slowly changing, with the gender disparity closing throughout Europe.

Reflecting on the information presented in the review, efforts should be made to develop engagement programs that encourage varied demographics who are classed as non-adopters. Examples of new users to create engagement programs:

- Users who are from low socio-economical backgrounds. Evidence indicates that there is a low uptake of eco-efficient systems amongst this group. However, these users stand to benefit quite a lot from co-sharing travel in terms to access to vehicles, lower travel and maintenance costs.
- Parents who are looking for other parents to share pick up/drop off responsibilities. Car-sharing users then essentially become the children represented by their parents, excluding the driver's. A system would need to combine user considerations of both adults/parents and children. However, Gamification could be used and directed at a younger audience that would encourage children to reinforce ideas of ride-sharing with their parents. Informing children of the benefits of ride-sharing could lead to behavior change that could carry over until they become old enough to drive. Considerations of child-car seats need to be discussed.
- Younger women who have fears of safety. Offering women only services or additional security measures, could help to quell some of the resistance concerning ride-sharing within this demographic. A look at 20 to 34-year-old women could help assess beliefs, motives and preferences for adopting ride-sharing.
- Older/elderly members of the public. Some members of this demographic no longer have access to a driving license but still want to maintain their mobility. Additionally, research indicates that this group of people could benefit from more social interactions, especially if they have no family/their spouse has passed away. Social networking and meeting new people via ride-sharing could not only improve moods but give them more mobility, comfort and safety than using public transport systems.
- Big social events such as football/sports, theatre, music gigs and festivals draw in a huge amount of people all travelling to the same location. Matching users to preferences, (to address some of the psychological barriers such as social awkwardness) has already been covered somewhat by a shared interest in the final destination.

This list of suggested new demographic users, could greatly benefit from adopting ride-sharing services within their daily travel arrangements. To ensure that maximum engagement Is achieved with each of these user groups, targeted Gamification and relevant services/training should be developed and made available to appeal to each individual group's needs.

Case: BlaBlaCar

BlaBlaCar represents a paradigmatic case for understanding how a social media based business model works. As a start-up company that has introduced a social media-based business model, they have reached a new market segment, that of so called "hitch-hikers 2.0". In this, they are leveraging web 2.0 technology (Delpriori, Freschi et al. 2015), having built the core of their business model based around the accessibility it provides. BlaBlaCar is an e-business company, that is competing via social media, and whose business model uses social media technology as a source of business model innovation. It is a particularly interesting case in that it has created a whole new market, that of the above mentioned "hitchhikers 2.0", allowing people (and even whole sections of the population) who never have done hitching before to engage in this practice (and share both its social and economic benefits) on an occasional or more frequent basis (Mazzella 2015).

BlaBlaCar is a French company, founded in 2004 by Frédéric Mazzella, Francis Nappez and Nicolas Brusson. In 2012 the company raised $10 million from Accel Partners (that has invested also in Facebook, Groupon, Dropbox among others), ISAI and Cabiedes & Partners. In the same year, BlaBlaCar merged with other similar European companies (e.g. postoauto.it, a start-up founded by Olivier Bremer in Italy in 2009). Today, BlaBlaCar.com has branches in UK, France, Italy, Spain, Holland, Luxembourg, Belgium, Poland, Portugal, Ukraine, Russia, Germany, India, Turkey, Mexico, Hungary, Croatia, Romania, Serbia, Brazil, Czech Republic and Slovakia, with a community of more than 25m users. Due to this extremely strong expansion, the company has been recently able to raise further $200m, primarily from US investors. Italy has been the country where its user base is growing the most, due to the particular impact of financial crises and the increase of gasoline price, although as a whole the bigger market still remains France, as of now (Mundler, Stocker et al. 2016).

BlaBlaCar works as an intermediary between its users: drivers can register, publish their trips and contact other members who are making the same trip. Similarly, passengers can contact drivers who have published the trip of interest, or just publish their trip and wait that other members contact him. BlaBlaCar.com thus links drivers with empty seats with passengers who are looking for a lift, and it charges (in some countries) a commission of the journey, applying to cars the same logic that AirBnB applies to accommodation (Casprini, Paraboschi et al. 2015).

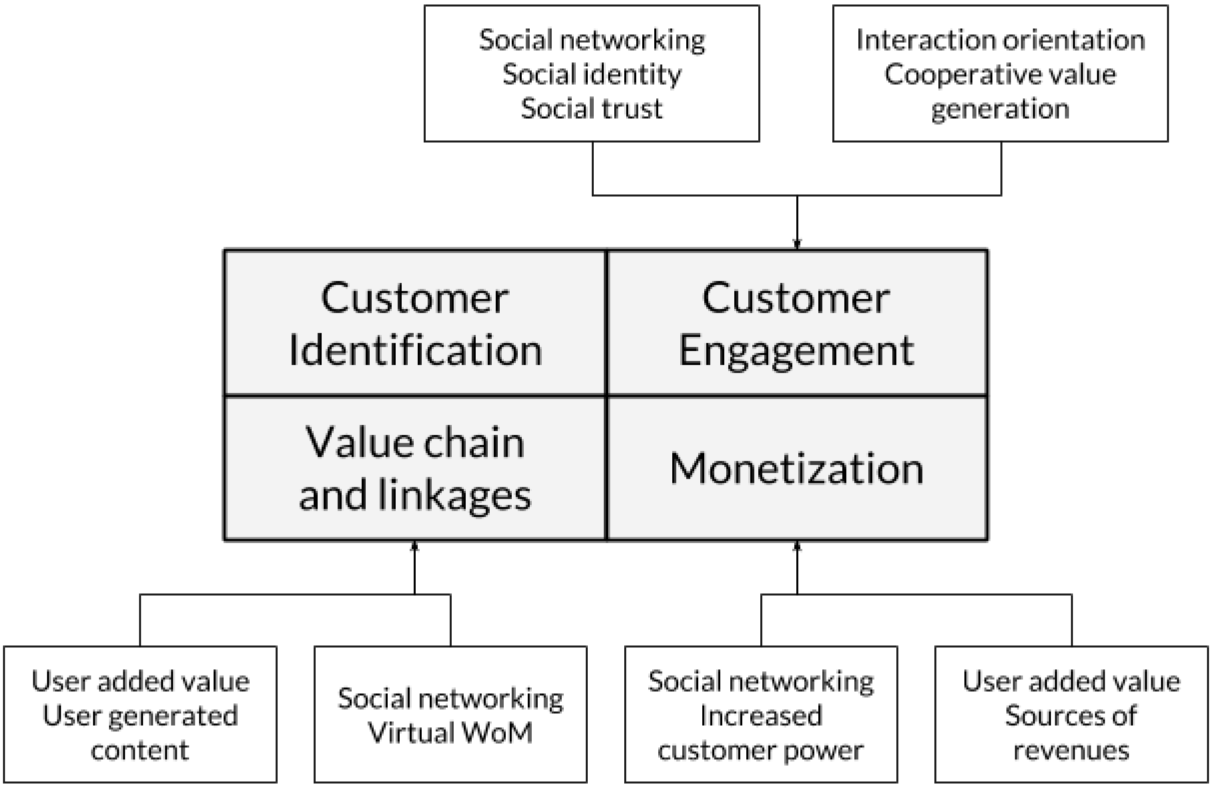


FIGURE 1. BlaBlaCar business model.

Figure 1 is an example of how a business model that was born for one particular industry; lodging (i.e. holiday accommodation), has been applied for another industry, the carpooling. BlaBlaCar.com is "a sort of social network", says Olivier Bremer, Italy Country Manager in an interview, "that has enabled a way to travel low-cost. But it is also a social experience, a way for travelling in a more social way". You can choose the persons you want to travel with and you can do it via the information provided in the website.

According to Bremer (Casprini, Paraboschi et al. 2015), four main factors help BlaBlaCar.com to grow.

1. The attention in building the right team. In BlaBlaCar.com, there is no hierarchy, but a horizontal organizational structure. A central feature for working in BlaBlaCar.com is the motivation and engagement of team members.
2. BlaBlaCar.com has had a lot of venture capitalists. This has given access not only to high financial resources derived from investors as Accel, but above all to the information and contacts that investors have.

3. An important factor is the replicability of the business model in other countries. If something works well in one country, it will work well also in another country. The knowledge can be easily analysed, especially for doing online marketing.
4. The network effects that characterized platforms in general: “the more the people use it, the more rides you will find close to your home, even if you’re going from a tiny city to another small city”, says Frédérick Mazzella.
5. Pricing is adjusted once the community is created. Once the reputation of the service has been created, it is applied a fee/commission and online payments are activated in order to favour transactions (Casprini, Paraboschi et al. 2015).

Research data on users is still sparse, or safeguarded as trade secret. However, a survey was conducted by Casprini (Casprini, Paraboschi et al. 2015), highlighting the socio-demographic profile of hitch-hikers 2.0. The survey was run in Italy during March 2014 to April 2014 and was run online, over the overall Italian BlaBlaCar.it community that counted almost 30.000 members. In total, 5.493 questionnaires were returned for a response rate of 19,93%. The sample was then divided among users that are only passengers (n1=2.270), users that are only drivers (n2=1.384) and both (n3=1.839). To the extent of this paper, we considered only passengers since they are the ‘pure’ hitchhikers 2.0.

Table 2 provides descriptive statistics, distinguishing also between people who have done hitchhiking before or not. From the analysis, in general, it results that they are young, with an average age of 31 years, mainly males, most of them have an income below 28.001 euros per year, stay connected with the web, most of them use BlaBlaCar for cost saving motives (e.g. for reaching faster a place), and consider feedback, information about price and time of departure as very important factors in order to choose the driver whom travel with. Finally, they feel part of a community.

TABLE 2. BlaBlaCar descriptive statistics of users.

	Overall					No hitch-hiking before					Hitch-hiking before					
	N	mean	sd	min	max	N	mean	sd	min	max	N	mean	sd	min	max	p-val
Frequency: occasionally	2194	0.6	0.49	0	1	1348	0.57	0.5	0	1	846	0.65	0.48	0	1	0.000
Frequency: 1-2 times per month	2194	0.29	0.45	0	1	1348	0.3	0.46	0	1	846	0.26	0.44	0	1	0.033
Frequency: 3-4 times per month	2194	0.08	0.27	0	1	1348	0.09	0.29	0	1	846	0.07	0.25	0	1	0.048
Frequency: more than 4 times per month	2194	0.03	0.17	0	1	1348	0.04	0.19	0	1	846	0.02	0.14	0	1	0.01
Age	2192	30.81	10.37	18	82	1347	30.07	9.93	18	82	845	32	10.93	18	75	0.000
Gender	2190	0.33	0.47	0	1	1346	0.31	0.46	0	1	844	0.35	0.48	0	1	0.036
Income: 0-5000 euros	2194	0.71	0.45	0	1	1348	0.7	0.46	0	1	846	0.73	0.45	0	1	0.219
Income: 5001-15000 euros	2194	0.11	0.31	0	1	1348	0.11	0.32	0	1	846	0.1	0.3	0	1	0.331
Income:15001-28000 euros	2194	0.12	0.32	0	1	1348	0.12	0.33	0	1	846	0.12	0.32	0	1	0.745
Income: 28001-55000 euros	2194	0.05	0.22	0	1	1348	0.05	0.22	0	1	846	0.05	0.21	0	1	0.525
Income: more than 5000 euros	2194	0.01	0.09	0	1	1348	0.01	0.09	0	1	846	0.01	0.08	0	1	0.93
Use of internet	2194	1.84	0.36	1	2	1348	1.87	0.33	1	2	846	1.79	0.41	1	2	0.000
Registered by 2 months	2194	0.12	0.32	0	1	1348	0.13	0.33	0	1	846	0.1	0.3	0	1	0.066
Registered between 2 and 6 months	2194	0.35	0.48	0	1	1348	0.37	0.48	0	1	846	0.33	0.47	0	1	0.031
Registered between 6 months and 1 year	2194	0.32	0.47	0	1	1348	0.34	0.47	0	1	846	0.31	0.46	0	1	0.145
Registered between 1 year and 2 years	2194	0.18	0.38	0	1	1348	0.14	0.35	0	1	846	0.23	0.42	0	1	0.000
Registered since more than 2 years	2194	0.03	0.16	0	1	1348	0.02	0.15	0	1	846	0.03	0.18	0	1	0.115
Use of websites similar to BlaBlaCar	2194	0.15	0.35	0	1	1348	0.11	0.31	0	1	846	0.2	0.4	0	1	0.000
Belongingness	2188	3.09	1.23	1	5	1344	3.09	1.23	1	5	844	3.09	1.24	1	5	0.998
Known_through	2187	1.73	0.45	1	2	1343	1.73	0.44	1	2	844	1.72	0.45	1	2	0.54
Feedback	2194	0.93	0.25	0	1	1348	0.94	0.24	0	1	846	0.93	0.26	0	1	0.334
Leave_suggestion	2191	0.04	0.2	0	1	1345	0.04	0.19	0	1	846	0.05	0.21	0	1	0.231
Price	2194	4.41	0.81	1	5	1348	4.42	0.8	1	5	846	4.39	0.82	1	5	0.378
Car comfort	2194	2.71	1.13	1	5	1348	2.79	1.14	1	5	846	2.58	1.11	1	5	0.000
Time dep.	2194	4.22	0.9	1	5	1348	4.28	0.88	1	5	846	4.12	0.93	1	5	0.001
Driver feedback	2194	4.35	0.9	1	5	1348	4.45	0.83	1	5	846	4.19	0.98	1	5	0.000
Habits	2194	2.86	1.2	1	5	1348	2.91	1.21	1	5	846	2.78	1.19	1	5	0.016
Known driver	2194	2.73	1.41	1	5	1348	2.87	1.4	1	5	846	2.51	1.38	1	5	0.000
Picture	2194	3.23	1.26	1	5	1348	3.35	1.25	1	5	846	3.05	1.26	1	5	0.000
Driver gender	2194	1.75	0.99	1	5	1348	1.83	1.04	1	5	846	1.62	0.9	1	5	0.000
Meeting people	2194	3.31	1.11	1	5	1348	3.23	1.12	1	5	846	3.44	1.09	1	5	0.000
Conv. better hour	2194	3.61	1.18	1	5	1348	3.66	1.17	1	5	846	3.54	1.19	1	5	0.017
Saving money	2194	4.67	0.64	1	5	1348	4.69	0.63	1	5	846	4.64	0.67	1	5	0.067
Conv. closeness	2194	3.56	1.18	1	5	1348	3.59	1.18	1	5	846	3.5	1.18	1	5	0.054
Conv. time	2194	3.69	1.24	1	5	1348	3.74	1.24	1	5	846	3.61	1.23	1	5	0.023
Polluting less	2194	3.72	1.23	1	5	1348	3.61	1.25	1	5	846	3.89	1.19	1	5	0.000

2.4.3. Road sensing

Road maintenance, is a rapidly growing area of concern for all members of the public, as without regular and effective plans for road monitoring and maintenance, serious risks that affect travel safety, costs and economy, environment and travel comfort (Robinson, Danielson et al. 1998) emerge. Damage to road surfaces are caused mainly by cumulative vehicle passages (the impact of vehicles going over the road and tearing it up). Different types and weights of vehicles cause various amounts of damage and with unanticipated growth in road utilization and economy, the road systems are under risk of becoming increasingly hard to preserve. In order to understand effects of traffic pressure and monitoring quality of road surface areas over time, the paradigm of road-sensing is proposed.

Road sensing operates by collecting travel and vehicle related data, gathered through sensors to track driving activities such as vehicle motion, trajectories and fuel consumption rates, etc. (Hu, Liu et al. 2013). In the developed world, intelligent transportation systems (ITS) are used to help track and manage these sensors which can range from GPS-based tracking sensors built into vehicles and/or road monitoring/management sensors that survey road use, traffic and accident reporting (Mohan, Padmanabhan et al. 2008). These systems however, can be expensive, both to install and to maintain. By employing mobile phone sensors to help measure some of these issues, this expense could be reduced dramatically, adopting a more shared public responsibility of road monitoring and management. Mohan et al., (Mohan, Padmanabhan et al. 2008) state that mobile phones provide access to the following functions that can be used to aid road monitoring:

- Computational capabilities: CPU, GPU.
- Operating system.
- Communication services: Cellular radio for basic cellular voice communication (e.g., GSM), available in all phones.
- Cellular data: e.g., GPRS, EDGE, UMTS.
- Local-area wireless: radios for local-area wireless communication (e.g., Bluetooth, WiFi).
- Sensing: Audio: microphone. Localization: GPS receiver.
- Motion sensing: accelerometer, sometimes included for functions such as gesture recognition.
- Visual: cameras.

Each of these functions are usually available to most smartphones meaning members of the public that have access to a smartphone are able to switch on an application and contribute to building a body of knowledge and data on their local road systems. Using a shared responsibility paradigm for maintaining the road systems, supports the development of healthy travel behaviors and assigns a more personal feeling of responsibility to individual members of the public. Presented in the next section is a review of SmartRoadSense, a crowd sensing software that utilizes mobile phone sensors to monitor quality of surface areas in the roads.

2.4.4. SmartRoadSense

SmartRoadSense (SRS) is a crowd sensing system for the continued monitoring of road state. SRS uses smartphones' accelerometers and GPS systems to detect and classify irregularities of the road surface and transmit them to a server which links them to the nearest road, collects data from all different users and shows the results on an interactive, public online map. Aggregate data are open and available online, so as to promote their use from the public (Alessandroni, Klopfenstein et al. 2014),

SmartRoadSense is aimed at estimating the quality of the road surface exploiting the sensors of a mobile device anchored to the car cabin. Using the data of the triaxial accelerometer and the vehicle speed provided by GPS system, it has been shown that an estimate of the quality of road surface can be obtained. In order to improve this estimate, the dependence of the mobile device vertical acceleration on the vehicle speed has been tested. Using a theoretical model and experimental results, it is shown how the average power of the vertical acceleration and the road roughness index estimated by SmartRoadSense are related to speed.

Monitoring of road surface conditions is a critical activity in transport infrastructure management. Many research solutions have been proposed in order to automatically control and check the quality of road surfaces. Most of them make use of expensive sensors embedded in vehicles or mainly focus on detection of specific anomalies during monitoring activity. Alessandroni et al. (Alessandroni, Klopfenstein et al. 2014) describe the design of a system for collaborative monitoring of road surface quality. The overall architecture encompasses the integration of a custom mobile application, a geo-referenced database system and a visualization front-end. Road surface condition is summarized through a roughness parameter computed using signal processing algorithms running on mobile devices. The roughness values computed are subsequently transmitted and stored into a back-end geographic information system enabling processing of aggregated traces and visualization of road conditions. The proposed approach introduces a thoroughly integrated system suitable for monitoring applications in a scalable, crowdsourcing collaborative setting, aimed at supporting collaborative monitoring of road surface roughness using mobile smart devices.

2.5. Socio-Economic analysis

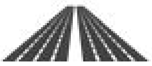
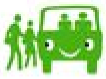
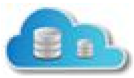
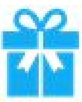
Alongside the review of the current literature surrounding the eco-efficient services; Ride-Sharing and Road Sensing technologies and the state of the current user's characteristics, the partner BucksADV composed a socio-economic analysis that would identify third party organizations who are transport and mobility policy makers. As part of the methodology for identifying a set of scenarios for the CROWD4ROADS project, the socio-economic analysis was discussed and examined alongside the literature review to form a series of scenarios to be used for the CROWD4ROADS project. Further information regarding the socio-economic analysis and the data pertaining to transport policy stakeholder groups, can be found in D2.2 Socio-Economic Analysis and Sustainability Threat.

3. Target user groups

Presented within this Chapter is an analysis of target user groups that have been identified via the needs assessment, for use in the prototyping of the CROWD4ROADS technologies. Each target group is put forward, discussed, and identified within the reference scenarios, in order to define specific use-cases in Chapter 5.

For each target user group, motivations, attitudes, impacts of the CROWD4ROADS project, overall impact, reach, and their expected behaviors are described. Behaviors in particular are expressed as *user stories*, based on a graphical depiction using the iconography presented in Table 3.

TABLE 3. Icon representations used in use cases.

Icon	Description
	User
	Municipality
	Gamification system
	Ride-sharing platform
	Road-sensing technologies
	Cloud storage & data
	Reward system

Target user groups can be visualized using a Venn diagram, as shown in Figure 2, indicating that the different user groups have overlapping regions composed of users that share characteristics of two or more groups.

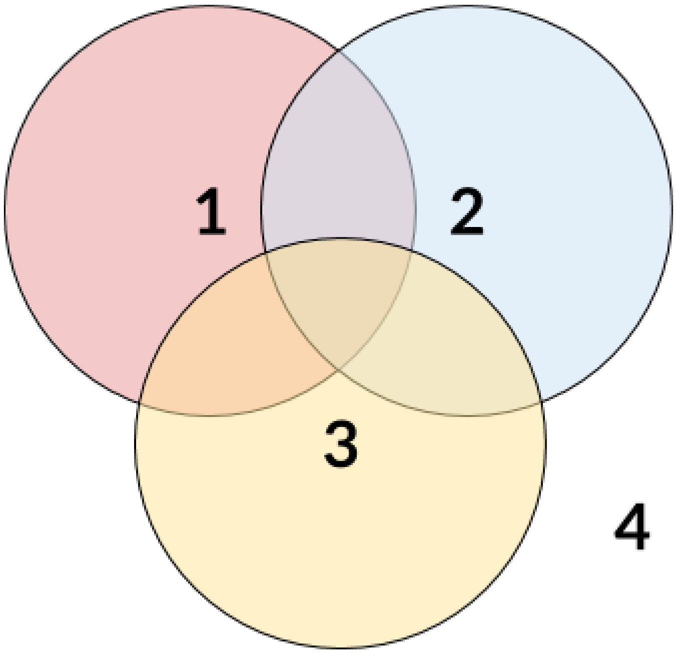


FIGURE 2. Relatonships between target user groups as a Venn diagram.

3.1. Group 1: Citizens willing to improve the conditions of the roads they travel on

Based on the socio-economic analysis carried out by BuckADV (D2.1 Socio-Economic Analysis and Sustainability Threat), the first scenario user group that was identified, is based on any public resident who may or may not yet be a member of an eco-efficient service such as ride-sharing or road-sensing. Residents and the general public in itself is a large and multi-varied audience to target, and may need to be broken down into several smaller target groups in order to develop an understanding on personal motivations for tailored incentives.

3.1.1. Motivations

In 2012, the National Highways & Transport Survey (NHT Survey) found that 61% of residents in England were dissatisfied with the condition of local roads. Only 27% were satisfied with the condition of this asset, giving a net satisfaction rating of minus 34%, much worse than for the years that preceded the recent hard winters (NHT Survey, 2012). During the 2010 General Election campaign, a RAC Foundation report found similar beliefs concerning the state of the roads. It was found that 58% of the public reported ‘condition of roads and pavements as one of the highest priorities for an incoming government. 2nd in the report at 46%, was ‘curbing the cost of driving’.

Based on these findings we can draw some conclusions as to the local concerns of the general public regarding road conditions and maintenance. It would appear that the general public place road maintenance as a high priority issue for their council and local government representatives to address. General motivations of this target group may come from more common concerns about the upkeep and conditions of the local roads or from a more general sense of civic duty. Members within this group may be more concerned with local roads and areas within their direct and surrounding residential area and therefore are vital for assessing the quality of smaller and less traveled roads and pathways. Financial rewards, money-off vouchers and local reward schemes may be utilized with this group to promote extrinsic motivations to engaging with eco-efficient services. To promote a greater sense of personal responsibility, a system that promotes the user to ‘watchman/person of authority’ of an area based on the number of uses/application of eco-efficient websites used. Following the general user overview of this group, we believe that based on the research outlined in the background review, we can develop more defined user’s groups such as parents, elderly members of society or young women as cases to target within this general user group scenario.

3.1.2. Attitudes

This general groups attitude to ridesharing has been identified as the following, following the socio-economic report:

- They are most likely to be motivated by a sense of civic duty or by a willingness to coöperate with local authorities.
- They are most likely to not be particularly motivated by the idea of taking up and participating in a ride-sharing practice. To develop a more positive attitude towards ride-sharing as a practice, rewards and extrinsic incentives are likely to have the greatest influence on their behaviour. These extrinsic rewards should be developed into the gamification platform in order to maximise pull and appeal of the ride-sharing platform to this group.
- Due to the nature of this target group and their original concern of the road conditions. It is most likely that they have their own access to vehicle transport. Bridging psychological barriers that were addressed in the literature review

such as: perceived effort, time taken and shared space with stranger's acceptance, will help to encourage this user group to engage with these services.

The group's attitude to road-sensing has been identified as the following:

- This group, because of their identified background and the likelihood that they are to report conditions of the roads, should in theory, be far more open to using a road-sensing application within their daily travel routines.
- Perceived benefit of use and ease of use are likely to be barriers to address concerning using a road-sensing application with this user group.

3.1.3. Impacts of Ride-Sharing

The impact of engaging this target group with utilizing ride-sharing services more for their daily travel needs, will have an overall positive effect on the environment. Less personal vehicle use, especially for routine, day to day travel such as commuting, school pick-ups etc. could lead to a healthier ecosystem surrounding the road networks. On a more personal scale, more money could be saved on travel expenditures with a greater uptake of ride-sharing services.

3.1.4. Impacts of Road-Sensing

Users from this group who utilize the road-sensing application could be helping to identify the conditions of the road in a more hands-on approach. This could help them feel as if they are contributing to something greater, and in turn, there should be less focus on direct complaints to the municipalities and more focus on aiding the council by identifying troubled spots. Furthermore, raising awareness of additional eco-efficient services within this group could help the promotion and development of a healthier approach to travel behaviors, that include looking into different types of eco-efficient services that could be adopted for everyday travel.

3.1.5. Overall Impact & Reach

Targeting this user group will allow the CROWD4ROADS project to try and have an impact within a public group who do not necessarily engage with eco-efficient services. This will allow us to monitor our impact and reach through adoption and uptake of services we intend to offer out. In turn, this will allow the CROWD4ROADS project to track and evaluate clearly, how engagement and motivation strategies such as the ‘gamification platform’ have performed. This target group are most likely to report on conditions of the roads if they believe them to be of poor quality. This exercise in itself is one led by an emotional anger or concern. By re-conditioning the behavior of this user group to instead become monitors of the roads and report back on its overall condition, a personal sense of responsibility, pride and camaraderie with the local council can be fostered instead with less emphasis on general complaints. In terms of the roads and the impact that this will have for the overall condition and what that means for municipalities, the consortium expects general road maintenance programmes to improve, a reduction to vehicle damage and operational costs, improved safety and a reduction in local road accidents and an improvement on journey times. The overall benefits of targeting this group, means that we are already reaching out to a group who are concerned with the overall conditions of the road. Invested interest means more of a likelihood in uptake of offered services, especially if coupled with a rewards system. Potential areas of concern are the wide-ranging backgrounds of this user group. More detailed demographic data, could help to develop strategies for better reach and involvement with the proposed CROWD4ROADS technologies.

3.1.6. Behaviors

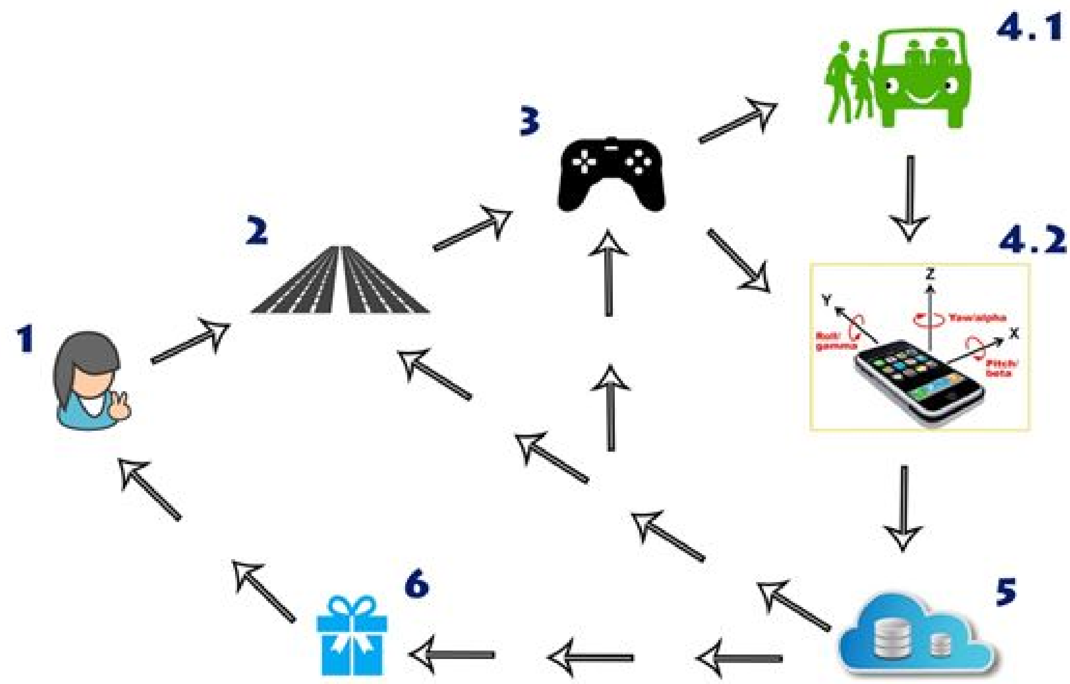


FIGURE 2. Sample system interaction of user group 1.

1. **User Onboarding (Step 1 to 2)**
   Users in this group have been identified as keen observers of road maintenance. Based on this evidence, Users (step 1) go to their local municipalities website/contact center (step 2) to report road issues. Within the municipalities website/contact centre is information/adverts that present a game connected to road-sensing technologies. Information is presented that informs the users of the benefits/purpose of the game/road-sensing technologies. The users are encouraged to sign up to the game through links hosted on the municipalities website/service to another webpage that will house the downloads for the game, road-sensing app and links to BlaBlaCar.
2. **Game Setup and Downloads (Step 2 to 3)**
   Users will be asked to set up for the game and a login in step 3.
3. **Road-Sensing Downloads (Step 3 to 4.1 & 4.2)**
   Once they are set-up and have a login, the users will be asked to download the road-sensing technologies in step 4.2. They will also be given the opportunity to

connect and sign up to BlaBlaCar services in step 4.1. Further in-depth information about the project and its purposes will be displayed in step 3.

4. **Game Interaction and Data (Step 4.2 to 5)**
   Once users start interacting with the game and the road-sensing technologies, the data gathered from these will be transferred to cloud data storage in step 5. This will house all user data gathered on roads and non-personal user data.
5. **Game Rewards and Data Feedback (Step 5 to 2 & 6)**
   Data gathered will be fed back to the municipality (step 2) to inform on the quality of the roads. Data will also be used to determine player rewards found in step 6 which will be fed back into the game system in step 3.

3.2. Group 2: Members of the BlaBlaCar community

3.2.1. Motivations

The concerns and motivations of this user group are likely to be highly influenced around the impact that roads and travel creates on the environment and the local eco-systems. Since these users already engage with ride-sharing services, they are likely to feel very motivated to the ideals that surround sustainable travel behavior and how they can cut their own carbon footprint further. This makes them great candidates for further exploration of other eco-efficient technologies such as ride-sharing. Aside from their concern surround environmental impacts, they are likely to be motivated through monetary savings. Since ride-sharing saves the passenger/driver a percentage of money on their journey, it is possible that this is also a key point as to their interest in these services.

3.2.2. Attitudes

This general groups attitude to ridesharing has been identified as the following, following the socio-economic report:

- They are highly motivated to engage with these ride-sharing technologies. As this group consists of already existing ride-sharing members, limited barriers are reported in this user group.

The group's attitude to road-sensing has been identified as the following:

- They are likely to have some concerns surrounding road quality and therefore may show some interest in using road-sensing technologies in their travel habits. There is some evidence to suggest that they would be inclined to use these technologies.

3.2.3. Impacts of Ride-Sharing

As these users are existing members of a ride-sharing community, they have already had a positive impact on various issues such as; the environment and road ecology, C02 reductions and reduction of road travel impact. Additional rewards may be offered to help sustain this behavior or to incentivize them to encourage their friends and family to adopt these services further.

3.2.4. Impacts of Road-Sensing

Existing ride-sharing users who engage with the additional services that are offered through road-sensing could look to positively impact the environment further. Allowing these users to see the positive impact they are creating with both technologies may increase intrinsic motivations and sustained behaviours. Additionally, users engaging with road-sensing technologies may impact the overall cost of monitoring the roads, which may lead to personal cost savings for the individual users.

3.2.5. Overall Impact & Reach

Overall, existing ride-sharing users are a user group who already have a big impact with eco-efficient services. As these users are likely already very motivated by their concerns on environmental and cost saving issues, they are viewed as highly likely to engage with additional eco-efficient services such as road-sensing. Utilising these users existing motivations to encourage them to reach out to additional non-ridesharing users (family/friends) through additional reward systems (gamification approaches) is likely to improve reach, and gain new members to both ride-sharing and road-sensing services. Furthermore, the overall impact for the roads and municipalities who manage maintenance, will have greater access to daily feedback concerning the quality of the roads, leading to savings in maintenance costs.

3.2.6. Behaviors

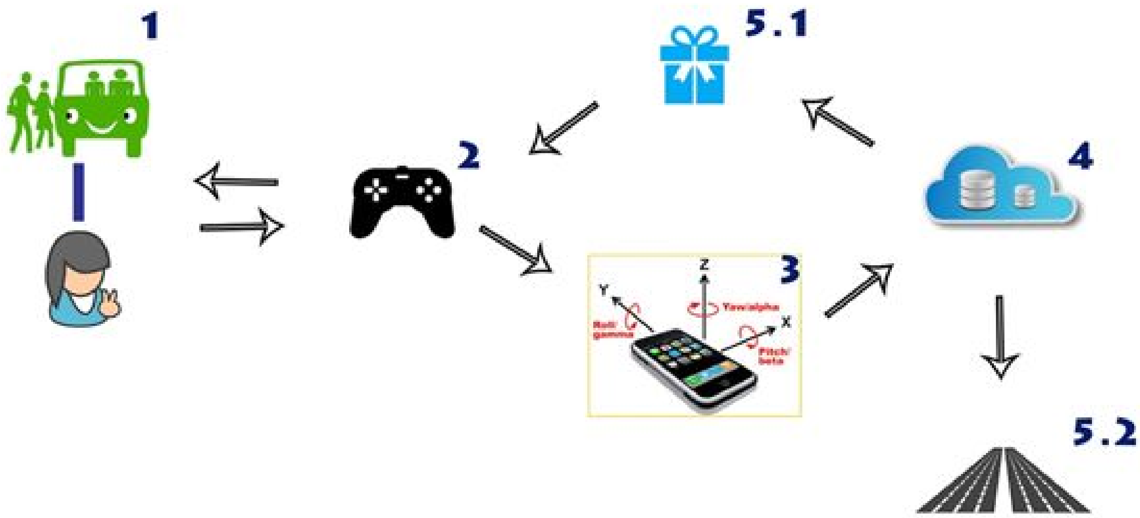


FIGURE 3. System interactions of group 3.

1. **Ride-Sharing User Onboarding (Step 1 to 2)**
   Adverts to be hosted on BlaBlaCar's system to existing ride-sharing customers advertising the game system. Information concerning the project and the game (overview) at this stage. Users are encouraged through extra incentives with BlaBlaCar to sign up to the game system.
2. **Game Setup and Downloads (Step 2 to 3)**
   Ride-sharing users will be asked to create a login for the game system and will be directed to step 3 to download the road-sensing technologies. Once they have downloaded all required systems, users can interact with the game and road-sensing technologies.
3. **Game Interaction and Data (Step 3 to 4)**
   Users interact with the game system and road-sensing technologies in step 3 which then feeds back data into the cloud storage system in step 4. Non-personal data, game data and road specific data is stored in step 4.
4. **Game Data to Rewards (Step 4 to 5.1)**
   Data is used from step 4 to inform the rewards system in step 5.1. Based on game outputs, rewards are allocated.
5. **Rewards to Game & User (Step 5.1 to 2 & 1)**
   In-game rewards are allocated based on data which feeds back from 5.1 to 2.

The user in step 1 can then access these rewards in the gamification system in step 2.

6. **Data to Municipality (Step 4 to 5.2)**
   Data that is stored in the cloud system in step 4 that is directly related to non-personal user data and road quality data, is fed through to the municipality in step 5.2. This data is then used in the appropriate way.

3.3. Group 3: Municipality personnel adopting SmartRoadSense as a road monitoring technology

Based on the socio-economic analysis carried out by BuckADV (D2.1 Socio-Economic Analysis and Sustainability Threat), the third scenario user group that was identified as the personnel of administrative entities or municipalities interested in spontaneously employing innovative tools for improving the efficiency of public services, especially in the increasingly underfunded and hard to manage field of road maintenance. Personnel of such entities are a large and diverse audience to target, and may need to be broken down into several smaller target groups, depending on the scope of individual roles (political, administrative, technical) and the specificities of the local contexts of their activities in order to develop an understanding on both personal and institutional motivations for tailored incentives and other positive outcomes.

3.3.1. Motivations

The EU 2014 Report on road surfaces discusses how, on a European level, total investment in road maintenance in 2011 amounted to £20 billion Euros, showing an evident trend to decrease in public expenditure starting with the economic crisis of 2008, with some countries (such as Bulgaria and Italy) decreasing their spending in this area up 40-50%. The same report highlights a meaningful correlation between decreases in expenditure and the number and gravity of incidents, which, even aside from the human costs, translate to further costs to the community, and to a vicious cycle bringing to a further reduction of road investment.

A paradigmatic example of this tendency, and an attempt to reverse them, are UK road maintenance investment policies. On 7th of April 2016 MP Andrew Jones addressed the issue of future opportunities for funding in road maintenance, highlighting how, beside the £1 billion between routine and structural maintenance, a special fund of £

578 million to fix potholes would be awarded to those municipalities that can demonstrate a more efficient record of road maintenance.

As the push toward efficiency in resource employment becomes stronger, municipalities need to find innovative techniques and tool to assess the quality of their roads, and to target maintenance and intervention in a sensible and efficient way.

Based on these findings we can draw some conclusions as to the concerns of municipal employees regarding road conditions and maintenance. Road maintenance has always been a high priority for municipality, as, especially for smaller municipalities, it constitutes a core issue of everyday administration, council level discussion and electoral discourse. General motivations of this target group may come from common concerns about the upkeep and conditions of the local roads, as members within this group will be strongly concerned with their direct and surrounding municipal area as defined by administrative regulations, and therefore can be key actors in for assessing the quality of whole urban or suburban areas. Cooperation and data sharing between different administrations could also be promoted and rewarded through the platform, encouraging a trans-municipality cooperation to build a wider mapping of road state situation and enact coordinated maintenance programmes.

The main rewards for this specific users will not come through the gamification platform, but will be inherent to the outcomes of the activity itself, from both an administrative and political standpoint, as through the use of transparent, open data generation and actions, the public effort to tackle the most immediate issues with local road maintenance can be made evident and open to public discussion and scrutiny.

3.3.2. Attitudes

This general groups attitude to ridesharing has been identified as the following, following the socio-economic report:

- They are most likely to not be very motivated by the idea of taking up and participating in a ride-sharing practice per se, as a practice independent from road-sensing and road state data collection. To develop a more positive attitude towards ride-sharing as a practice, a strong and sound connection with the road-sensing platform should be provided, highlighting the links between its use and the generation (via redundant monitoring) of clear, open and actionable feedback in the form of road state and use data. This feedback could be implemented into the gamification platform in order to maximise pull and appeal of the ride-sharing platform to this group, but it is key that the feedback provides useful patterns for administrative actions.

- Due to the nature of this target group and their original concern of the road conditions. It is most likely that they will leverage a variety of public venues for monitoring and transportation. However, the platform will also aim at changing the patterns in private transportation of municipal employees, using gamification to motivate them to utilise the same variety of means of transportation used by the general population, and experience, assess and evidence their everyday issues.

The group's attitude to road-sensing has been identified as the following:

- This group, because of their identified background and the likelihood that they are to report conditions of the roads, should, in theory, be strongly motivated to using a road-sensing application within their daily travel routines, but most importantly to strongly promote the use of road-sensing in their municipality through both institutional and informal means.
- Perceived benefit of use (in the form of increased road maintenance program efficiency) and ease of use are likely to be barriers to address concerning using a road-sensing application with this user group.

3.3.3. Impacts of Ride-Sharing

The impact of engaging this target group with utilizing ride-sharing services more for their daily travel needs, will in itself have only a marginal positive effect on the environment, if they don't also promote the use of services within their municipality both through institutional and informal means. However, less personal vehicle use, especially when a municipal employee consistently shares its mobility patterns (and car rides) with the general population, can bring to a much higher awareness of issues with private and public transportation in the local area, even beyond the quantitative evidence provided by road sensing.

3.3.4. Impacts of Road-Sensing

Road sensing is the main avenue for impact within this group: the system will provide the municipal employees and the administrators with open data on how and where to operate, and a transparent way for the public to witness the efficiency and the priorities of the municipality. A proper use of road state monitoring and of the emerging data will reduce the cost municipalities need to spend on 'contractors' which in turn will reduce their insurance premiums (as the data will enables municipalities to deliver a better programme of planned maintenance).

3.3.5. Overall Impact

Ethically, because this tool would help municipalities avoid paying out against insurance claims for damage caused to vehicles because of poor roads, funds saved can are reinvested into helping communities that have previously struggled accessing transport solutions, especially if ride-sharing has brought to an improved awareness of the realities of moving within the local area. Funds generated could also potentially be invested in supporting new models of Public Transport for Disadvantaged/Low Wage Communities; Social Care Transport and/or Home to School Transport, translating efficiency in road maintenance into widespread public utility and satisfaction.

3.3.6. Behaviors

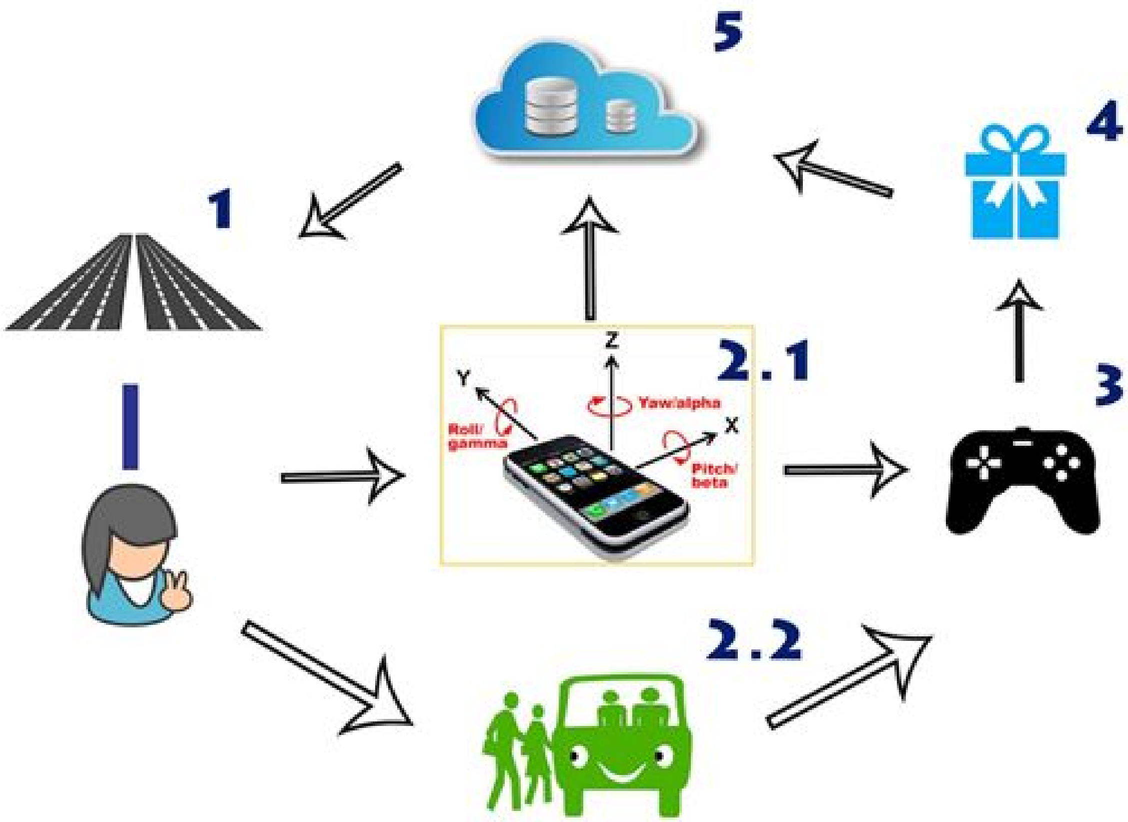


FIGURE 4. System interactions for group 3.

1. **Municipality Employees – Road-Sensing (Step 1 to 2.1)**
   Employees of municipalities spontaneously adopt crowd-sourced road sensing technologies in step 2.1, in accordance with their reference entity or employer. They can then use these technologies whilst they are traveling by road for personal, business, and work related purposes.
2. **Municipality Employees – Ride-Sharing (Step 1 to 2.2)**
   Given the nature of the crowd-sensing technologies adopted, they can also be used when ride-sharing for personal or business purposes, possibly making use of carpooling services in step 2.2.
3. **Road-Sensing Data to Cloud (Step 2.1 to 5)**
   Data gathered through crowd-sensing will go straight to the SmartRoadSense cloud storage, without further interaction with the reference entity (or employer) nor effort by other personnel.
4. **Road-Sensing to Gamification Platform (Step 2.1 to 3)**
   People who use the road-sensing technologies in step 2.1 are made aware of the gamification system and are asked if they would like to play in step 3. In step 3 they will be asked to create a login. The users can then interact with the game system that overlays the road-sensing technologies.
5. **Ride-Sharing to Gamification Platform (Step 2.2 to 3)**
   People who wish to engage with the additional services offered by BlaBlaCar in step 2.2 will also be given the option to opt into the gamification platform in step 3.
6. **Gamification Platform to Reward System (Step 3 to 4)**
   People users who engage with the gamification platform in step 3 will receive rewards and recognition based on their interaction with the road-sensing technologies. These reward systems are tracked in step 4.
7. **Reward System to Cloud Data (Step 4 to 5)**
   Rewards that are tracked within step 4 that are related to user and road data will be transferred to the cloud storage in step 5.
8. **Cloud Data to Municipality (Step 5 to 6)**
   All data relating to relevant user information, rewards and road-sensing information is accessible from cloud services, thus being accessible by individual users, municipalities, employers, and any other entity. This data can be then used to inform future road-maintenance issues by the personnel itself or any mentioned entity.

3.4. Group 4: Everybody else

Drivers or passengers not included in any of the groups above.

4. Scenarios

This chapter includes an example of geo-political and social environments that have been identified as possible application scenarios via the needs assessment, for use in the prototyping of CROWD4ROADS. Each scenario can be thought of an environment where one or more user groups, described in the previous chapter, can take an active part in specific use-cases, described in Chapter 5.

Like target user groups, scenarios can be represented using a Venn diagram, as shown in Figure 3. Scenarios have overlapping regions, composed of environments that share the characteristics of more base scenarios.

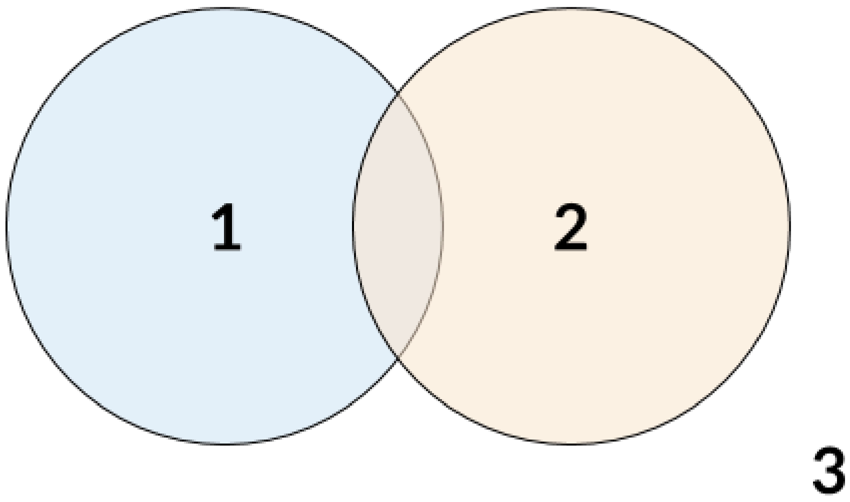


FIGURE 3. Relationships between scenarios as a Venn diagram.

4.1. Scenario 1: Region administered by an entity willing to involve citizens in road sustainability activities

In this scenario, a political region, an area, or a possibly complex infrastructure system, is administered by a public or private entity that is aware of CROWD4ROADS (or of individual trip-sharing and road-sensing initiatives) and is willing to involve stakeholders of its reference region to take active part in road sustainability activities.

This includes:

- Administrative districts aware of SmartRoadSense and willing to emply it to perform infrastructure quality crowd-sensing;
- Private infrastructure companies willing to adopt CROWD4ROADS-related technologies to perform road-sensing and reduce road traffic through carpooling;
- Municipalities willing to adopt innovative technologies in order to tackle road maintenance cost and to reduce traffic.

4.2. Scenario 2: Region with a strong penetration of BlaBlaCar

In this scenario, a political region or a geographical area has a high penetration of BlaBlaCar users, actively making use of ride-sharing and carpooling.

This includes:

- Nations or administrative districts where BlaBlaCar has a local office or benefits from high visibility in terms of market share or communication efforts;
- Nations or administrative districts where BlaBlaCar services are in high use.

4.3. Scenario 3: Any other region

Regions or areas not included in any other scenario above.

5. Use cases

5.1. Use case 1: From crowdsensing to carpooling

Citizens that perceive public road maintenance as a high priority issue for their local community or that are pushed by a sense of civic duty (part of target user group 1, based on the analysis in Chapter 3), in the context of a region administered by entity interested or involved in CROWD4ROADS-related activities or has adopted *SmartRoadSense* in some way (as identified in scenario 1 in Chapter 4), are encouraged to adopt carpooling for personal, business, and work related purposes by the administrative entity itself.

Encouragement can be dispensed in the form of communication initiatives, local incentives specific to the scenario or region, promotion of the C4Rs project, or other rewards.

5.2. Use case 2: From carpooling to crowdsensing

Users interested in BlaBlaCar who actively use its carpooling services (target user group 2), that live in an area where carpooling is widespread (scenario 2), or that are generally interested in the service (scenario 3), are reached by a direct CROWD4ROADS-related communication initiative (see Deliverable 5.2).

This input encourages users to familiarize themselves with CROWD4ROADS and related technologies, possibly also encouraging them to get interested in crowd-sensing and in taking part to monitoring road quality through *SmartRoadSense*.

5.3. Use case 3: Onboarding newcomers

Non-engaged user (target user group 4) is reached by information about CROWD4ROADS-related initiatives, either through direct communication methods or through word-of-mouth (for instance in a region implicated with a CROWD4ROADS pilot or replica thereof) is encouraged to take part either in crowd-sensing or to adopt carpooling for personal or work related reasons.

5.4. Use case 4: Local propagation

Non-engaged users (target user group 4) is approached by an engaged user who actively takes part in CROWD4ROADS-related activities (target user group 1). Based on the engaged user's civic duty or interest in rewards connected to the use of carpooling or crowdsensing, the user persuades non-engaged users to take interest in CROWD4ROADS initiatives.

This use case is particularly applicable in regions where administrative entities are stakeholders in the project itself (scenario 1) because of the additional rewards and incentives that can interest engaged users.

5.5. Use case 5: Traveling contamination

Two or more people carpooling (target user group 2), of whom one or more are already interested in *SmartRoadSense* (target user group 1). Through word-of-mouth or through incentives provided by multi-user gamification initiatives activated throughout the CROWD4ROADS project, the engaged users induces the other ones to take interest in the project and to adopt crowd-sensing through *SmartRoadSense* in order to gain benefits: both in the larger sense in terms of road sustainability and in the smaller sense in gaining access to rewards bestowed only through multi-user usage of the platform.

6. Conclusions

Task 2.2. has fruitfully evidenced new avenues for research and impact through the implementation of the CROWD4ROADS ecosystem.

The European level needs assessment highlights the huge relevance of road infrastructure and its state for the economy and the societal, environmental, economic impact of low car occupancy. The report discusses the present soft policy pushes toward more economically and environmentally sustainable transportation models, among which car sharing is a relevant emerging opportunity.

The literature review highlighted how the field is still in its nascent stage, and lacks an extensive field validation. While ride-sharing is a strongly emerging trend, also due to the economic crisis, research in this field has mostly been conducted by providers themselves, thus presenting an evident marketing oriented bent. Still, the extensiveness of the communities provides interesting demographic data, pointing at categories that could be fruitfully target to improve engagement (e.g. women, families, senior citizens).

As for road sensing, the exploration of research literature shows a field still largely confined, up until now, to laboratory experiments and specific urban areas. In this perspective the CROWDS4ROADS ecosystem is an unprecedented opportunity for research into large scale, open data collection pertaining public roads and urban contexts.

Basing on both the needs assessment and the literature review, three main scenarios for user engagement have been presented, aiming at three specific target groups, diverse in their motivation and affordances.

- Residents who might be engaged in experimenting with both ride sharing and road sensing, highlighting the opportunities for community building, environmental awareness and economic ease of access and savings.
- Active ride-sharers, who might be influenced to complement their ordinary transport practices with road sensing, leveraging the already existing communities to highlight the opportunities for promoting environmental awareness and preservation.

- Municipal employees, who might use the integrated CROWD4ROADS ecosystem to obtain and organise open data toward improving road maintenance and transportation programmes.

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