C-MOBILE

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Accelerating C-ITS Mobility Innovation and deployment in Europe

D4.5 Final Business Models

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Abbreviations

Abbreviation	Definition
3G	3rd generation of mobile telecommunications technology
C-ITS	Cooperative Intelligent Transport Systems
BASE/X	Business Agility through Cross-organisational Business Engineering
SDBM/R	Service-Dominant Business Model Radar
GLOSA	Green Light Optimal Speed Advisory
RSU	Road-Side Unit
OBU	On-Board Unit
VRU	Vulnerable Road User; e.g., pedestrians, cyclists
HGV	Heavy Goods Vehicle; e.g., trucks, lorries

Executive Summary

In the past decade, there has been tremendous progress in the field of intelligent transport systems; several successful cooperative mobility initiatives have proven potential benefits of cooperative systems in increasing both energy efficiency and safety for specific transport modes. A large variety of cooperative applications have been designed for different goals, stakeholders or specific settings / environments, however following a silo-based approach and resulting in independent deployments which, at the same time, have similar goals and functionalities for the end-user. Scalability, IT-security, decentralization and operator openness are some of the most important properties that a technical and commercial successful solution must provide.

C-MobILE aims to stimulate / push existing and new sites towards large-scale, real-life C-ITS deployments interoperable across Europe. Well-defined operational procedures will lead to decentralized and dynamic coupling of systems, services and stakeholders across national and organizational borders in an open, but secure C-ITS ecosystem, enabled by different access technologies which provide transparent usage for service providers and seamless and continuous experience for the end-users across different transport modes, environments and countries.

Although C-ITS services and their implementation are of prime interest within this project, successful marketization and adoption of these services significantly depend on the business models which encapsulate these services. After all, a technological innovation does not guarantee business or economic success. The development of a technology product should be coupled with a business model defining the context where its use is valuable for a particular user. Hence, implementing C-ITS services without a clear goal or without being directed towards the main beneficiaries of these services is more likely to lead to a failure. Specifically, it is important that the business models surrounding these C-ITS services are viable and sustainable. Inviable business models force users or stakeholders to incur unacceptable losses, whereas unsustainable business models will not survive the long-term horizon for which the services are able to generate value. This also hinders large-scale deployment of these services. Therefore, exploring the design of business models surrounding the use of C-ITS services is of high importance. The design of a business model should make clear what value will be offered through the mobility solutions that employ C-ITS services, which stakeholders will be involved and what responsibilities each stakeholder will have in implementing these mobility solutions. Moreover, it should become apparent how costs and benefits are distributed among stakeholders after the implementation. In turn, business model blueprints may serve as a plan for implementing C-ITS services and as an incentive for stakeholders to participate in scenarios using these services.

Past European projects within the C-ITS mobility domain, such as Compass4D [1], or ongoing projects, such as NEWBITS [2], have acknowledged the need for exploring business opportunities and deriving business models to support the deployment of these services. In Compass4D, business models for deploying C-ITS services have been designed with the Business Model Canvas. As a result, the designed business models adopt a more organisation-centric view, reasoning from the perspective of the municipality for a deployment site. However, C-ITS services are not deployed in isolation by a single organisation, but are the product of collaborations between multiple stakeholders within the business model, including authorities, municipalities, infrastructure providers, service providers and users. Therefore, there is a need for exploring business models for C-ITS services from a networked business perspective, examining the role of involved stakeholders within such a business collaboration. The NEWBITS project does aim to consider business models from a networked business perspective, however, is still in its early stages (in which business model deliverables are yet not present).

In this project, we take an explicit networked perspective for creating solution-oriented mobility services to users. We organized workshops at each C-MobILE deployment site, and with the participation of several stakeholders at each site, we collaboratively designed business model blueprints for mobility solutions that use C-ITS services, and reported them in D2.5 Initial Business Models submitted in M9 (Feb 2018). This D4.5 report presents the *final versions* of these blueprints, which elaborate on how value is created for all stakeholders through applications of C-ITS services, describes the role of the stakeholders involved, cost and benefit items incurred by each and how these items flow among different stakeholders. More specifically, in the time period between M10 and M47, we have:

- collaborated with the local sites to assess how the initial plans unfolded, and to monitor for the emergence of new solution scenarios and for the improvement of existing (initial) ones,
- performed workshops and meetings to elicit these new or updated scenarios, and developed new business model blueprints to cover *all* C-ITS services deployed in the C-MobILE deployment sites,
- refined and consolidated these blueprints into 12 business model blueprints -each incorporating a set of C-ITS services for the solutions of specific mobility challenges of urban areas, and generalized them for adoption in any European city challenged by similar problems or opportunities,
- detailed each blueprint with specific value capture flows (that depict how the cost and benefit item flow among stakeholders), and with choreography diagrams (that depict the underlying scenario of the model),
- performed a survey among C-MobILE consortium partners – focusing on local sites – to *qualitatively* evaluate the viability and feasibility of the blueprints,
- finally, performed a series of online workshops with several C-MobILE consortium partners involved in the deployments in local sites, to *quantitatively* evaluate the feasibility of the blueprint business models.

In addition, based on the consolidated set of 10 blueprints, we have generated a *reference business model blueprint* that can be used as a template for the design of new business model blueprints for C-ITS-enabled mobility solutions. The final blueprints aim to provide guidance for the implementation of C-ITS services, emphasizing the importance of creating viable and sustainable business networks. A blueprint covers one or more C-ITS services, depending on the specific needs and goals of the involved stakeholders, and as such, can serve as guidance on how these services can successfully be put in practice. Finally, in this report, we discuss our recommendations for fostering business model design for the C-ITS-enabled mobility solutions.

Acknowledgements

Over 120 people from different organizations -many of which are in the C-MobILE project consortium- have participated in the business model blueprint design workshops, in the review process of the resulting models, or contributed to the blueprint design with their feedback in several gatherings and meetings. We would like to thank all participants for their valuable input and contributions.

1. Introduction

1.1. C-MobILE at a glance

The C-MobILE (Accelerating C-ITS Mobility Innovation and depLoyment in Europe) vision is a fully safe & efficient road transport without casualties and serious injuries on European roads, in particular in complex urban areas and for Vulnerable Road Users. We envision a congestion-free, sustainable and economically viable mobility, minimizing the environmental impact of road transport. C-MobILE will set the basis for large-scale deployments in Europe, elevating research pilot sites to deployment locations of sustainable services that are supported by local authorities, using a shared approach that ensures interoperability and seamless availability of services towards acceptable end-user cost and positive business case for parties in the supply chain.

1.2. Objective

The objective of this document is to communicate part of the results of the Task T4.3 and as such to present a set of business model blueprints designed in collaboration with all C-MobILE local sites and parties. In designing business model blueprints, we used the service-dominant business model-radar (SDBM/R) that puts emphasis on co-creating value for all involved stakeholders (including the customer), and as such serve as an incentive for all stakeholders to participate. Each business model blueprint presented in this document has emerged from stakeholder workshops at deployment sites within the C-MobILE project and reported in the D2.5 initial business models. The initial business model blueprints are catered to the specific needs and context of the respective local site, while the final versions of the blueprints are extended and generalized version that are designed to guide and inspire C-ITS deployments in other cities outside the C-MobILE context.

1.3. Intended audience

This document is intended for all stakeholders/parties which have specific mobility challenges in their regions and are seeking for solutions that involve the deployment of C-ITS services. Service and technology providers, which offer C-ITS and related services, would also find these blueprints useful in (re-)positioning their offerings as components of the mobility solutions that are valuable to end-users in specific and well-defined contexts. They may also find these business model blueprints useful in exploring new mobility solutions that incorporate C-ITS service deployments.

1.4. Approach

Currently, many developments are taking place in the field of mobility, transportation, and traffic management. Many of these initiatives, however, have a hard time finding their way to practical, large-scale exploitation. One of the reasons behind this is the limited view on business models. Many of these developments have a technology-push character, where solutions are developed inside-out, with a focus on the technology in the mobility transportation from the very start, and with limited attention for actual business deployment at the end. This situation is made worse by the fact that complex mobility scenarios involve a multitude of stakeholders, each having their own business interests which need to be aligned with others'.

Several initiatives in the C-ITS domain (e.g., Compass4D [1], NEWBITS [2]) emphasize the need for exploring the opportunities to derive business models to support large-scale deployment and long-term sustainable operation of C-ITS services. However, business models designed in such initiatives typically address an organisation-centric view, reasoning from the perspective of a single party in a specific site. However, C-ITS services are not deployed in isolation by a single organisation, but are the product of collaborations between multiple stakeholders, including authorities, municipalities, infrastructure providers, service providers and users. Therefore, there is a need for exploring business models for C-ITS services from a networked business perspective, examining the role of involved stakeholders within such a business collaboration. Networked, service-dominant business models can address this need.

Recent projects on the design of agile, service-dominant business models in multi-stakeholder contexts in the mobility landscape have shown that the application of such a business design approach offers a constructive, collaborative way to develop blueprints for the definition of cases of concrete added value of mobility technologies and new forms of business collaboration to realize these cases of added value [3]–[5]. A service-dominant business model identifies the value proposition of a solution to the customer or end-user, high-level capabilities required by each party (organizations, institutions, companies, customers, etc.) participating in the model, as well as the expected costs and benefits. The business models (BMs) for a service (or a coherent collection of services) provide a solid basis for the requirements for the solutions and cost & benefit analysis for such solutions.

Adopting a service-dominant perspective, we initiated the tasks for designing blueprint business models for the C-ITS services and service bundles in collaboration with the stakeholders in the C-MobILE deployment sites. The conceptual tool used as a guiding reference for business model design is the SDBM/R (Service-Dominant Business Model Radar) [6]. The SDBM/R that has been successfully used in business model design in several domains - particularly in mobility and traffic management [4], [5], [7]–[10]. It adopts a networked perspective for designing business models, facilitating the identification and incorporation of all stakeholders concurrently for implementing C-ITS services. Moreover, the SDBM/R explicitly focuses on the value propositions that is enabled by the C-ITS service (*value-in-use*), and how this value can be appropriated to the customer, as well as other stakeholders involved [11]. As such, the SDBM/R is able to incorporate the specific characteristics of these C-ITS business models, which typically involve multiple concurrent actors for deploying C-ITS services, for which it is difficult to appropriate how value is created and distributed within this collaboration (as well as for the customer). Moreover, it contrasts business model design methods as the Business Model Canvas [12] used in previous initiatives or projects, which are more organization-centric. For these methods, it may become difficult to represent how value is created, appropriated and distributed amongst all stakeholders involved in these C-ITS-enabled solutions [13].

For the *initial* versions of the business model blueprints reported in D2.5 [14], we have organized a number of workshops in C-MobILE deployment sites to help engage relevant stakeholders (partners, associate partners, and other third-party stakeholders in the region) in collaboratively designing business model blueprints for sustainable deployment and operation of C-ITS services. (A list of the specific workshops, as well as the dates these have been conducted can be found in Table 13 in Appendices.)

For the final versions of the business models reported in this deliverable, we have continued conducting workshops and meetings with several stakeholders – those not only within the C-MobILE consortium but beyond - to reflect the perspective of a broader range of parties and representatives operating in the mobility and related domains. Upfront, participants in the workshops (particularly the deployment site leaders) were asked to consider the mobility challenges faced in their region/city, and elicit the potential use of C-ITS services to address these challenges that were deemed most important in their local context. The deployment site leaders were asked to invite a selected group of stakeholders, which would be involved in the deployment of the C-ITS services and solutions, potential (end) users of the services, or interested in joining or contributing to these business collaborations.

Taking all the local/concrete business model blueprints that have been designed as a result of these workshops and meetings, we have generated three main contributions: First, we have defined a *consolidated list of generic business model blueprints* that address current or future challenges of urban areas, together with their operating and value-capture scenarios depicting the inner-workings of the business models, and the exchange of costs-benefits among stakeholders, respectively. We have evaluated the validity and feasibility of the business model blueprints through a survey and through a series of workshops with parties involved in the deployments in the C-MobILE sites. Second, based on the consolidated list of blueprints, we have designed a *reference business model template* that can be used as a starting point to facilitate the innovation of new business models leveraging C-ITS services as a means to address mobility challenges. Finally, and as the third contribution, we present our *recommendations* based on the lessons learned in the design of business models in the mobility domain, and more specifically for those solutions that involve the deployments of C-ITS services.

1.5. Document structure

The remainder of the document is structured as follows. Section 2 discusses the business model design method that we have adopted in this project. Sections 3 to 13 presents the final business model blueprints that are the consolidated and generalized versions of the blueprints emerged from the stakeholder workshops. In these sections, each business model design is discussed in detail with potential variants. Section 14 introduces the survey conducted for the qualitative evaluation of business model blueprints and discusses survey results. Section 15 introduces a reference blueprint for the design of business models in the smart mobility domain that aims to facilitate blueprint design of new business models. In Section 16, we present our lessons learned and our recommendations to foster business model design in the mobility domain. Finally, Section 17 presents our concluding remarks. In the Appendices, we also provide additional content that might be useful in the deployment of future business models. In Appendix-F, for instance, we present an overview of the basic pricing strategies that can be used in the design of C-ITS-enabled mobility solutions.

1.6. Use disclaimer

The Service-Dominant Business Model Radar (SDBM/R) is a research product which has been developed in and as such belong to the Eindhoven University of Technology. The research performed by TU/e is intended for general use. However, no part of these products can be used in any form without explicitly acknowledging the following source: [6].

2. Method followed for Business Model Design and Evaluation

The business model in essence describes the logic of how a value is proposed for the customer, the costs and benefits that emerge from the business model, as well as how the outcomes of the model relates to the strategic decision making of the organisations involved [15]–[17]. Several tools have been proposed for guiding the design of business models. A prominent example is the Business Model Canvas (BMC) [12]. However, these approaches usually do not adopt a service-dominant perspective and do not accommodate a networked view of business models, in which value is co-created through a collaboration of multiple organisations. Therefore, for representing such models, the Service-Dominant Business Model Radar (SDBM/R) is introduced in [6], [18]–[20] which takes service-dominant logic as the basis. Figure 1 depicts the SDBM/R template.

Figure 1: Template of SDBM/R

At the heart of the radar is the co-created *value-in-use*, which describes the proposed value of the service solution for (and with) the customer. The central co-created value-in-use is encapsulated by three outer rings, for which each ring is divided into slices based on the number of stakeholders involved (and as such created a networked view). Each 'pie slice' represents the organisation-specific contributions (to be) provided or received to create the central value-in-use. The *actor value proposition* ring describes the value contribution that each stakeholder offers in order to create the central value-in-use. This value proposition may be directly related to or part of the central value-in-use (core partner) or may enhance the value proposition of other stakeholders (enriching partner). The *actor coproduction activity* ring describes the activity an organisation conducts or performs in order to offer their respective value proposition (i.e., *actor service*). Lastly, the *actor costs and benefits* ring describes the specific costs and benefits that each stakeholder accrues or generates when participating in the solution. These costs and benefits can be *financial*, but also *non-financial* (for instance social or environmental benefits) in nature.

The SDBM/R has been successfully applied in a set of industry projects to represent networked business models, for which the results on its application and evaluation have been communicated with scholars in a number of publications [6]-[8], [19], [21]-[24].

An SDBM/R blueprint is typically designed in a workshop setting where several stakeholders that would be potentially involved in the development of the solution participate (different stakeholder types are detailed in Section 2.1). We have conducted several workshops with the participation of stakeholders in the mobility domain to design and synthesise business models that involve the deployment of C-ITS services. Such a workshop consists of two phases. The first phase involves a tutorial on the concept of service-dominant business, and on the use of SDBM/R. The second phase comprises the core of the interactive design of a particular business model blueprint using the SDBM/R under the guidance of the business model design team. Following a practical approach, large posters and 'post-its' are used to represent the SDBM/R blueprints and its specific elements.

The blueprinting performed in the C-MobILE project involved the analysis of the stakeholders (including the customer, the focal organization that orchestrates the service, and other required parties), their exact added value (in qualitative terms), and the cost/benefit structure in a business network of these parties. Emphasis is put on the value created by the C-ITS-enabled mobility solution, and how each stakeholder may contribute and benefit from this business collaboration. Each workshop concluded with one or two draft business model blueprints. Each blueprint draft was completed and sent for review to the stakeholders who participated in the workshops. The blueprint business models were consequently finalized based on the feedback received and further discussions with the stakeholders in local sites. Each blueprint acts as a guideline in understanding and presenting the operative and economic aspect of the solution.

To assess the viability for the set of service-dominant business model blueprints, we orchestrated a series of online workshops with several partners involved in the deployments for each of the deployment sites. Based on the mapping between each business model blueprint and the deployments in each site, each workshop focused on a single blueprint. Preceding each workshop, we generated preliminary or tentative Excel spreadsheets concerning the financial costs and benefits indicated per business model blueprint. These spreadsheets detail the parameters and sub parameters expected to be required to concretize the costs and benefits per actor in the business model. In addition, the Excel sheet details per actor what balance of costs and benefits is obtained under the selected parameter settings, expressed in variable (e.g. per year) and fixed (e.g. one-time) terms.

Using the Excel spreadsheets as input, in each of the workshops we discussed three points:

- The characteristics of the deployments, e.g., C-ITS services that have been involved, number of current or potential service users
- The costs associated with the deployments including the purchase, deployment and operational or maintenance costs
- The benefits (realised or expected) of the operation of C-ITS services underlying a business model blueprint

Where applicable, we took the figures and information received for the parameters directly into account for the generated Excel sheets for calculating the viability of each business model blueprint. In case different parameters were considered, we updated the Excel sheets accordingly. In case deployment site stakeholders were not or only partially able to determine the appropriate values for the parameters included, we took the information received as a basis for further calculations, and extrapolated the input received to come up with values that would be applicable for the BM blueprint scenarios. In case no information could be provided, we have drawn upon different sources (internal sources such as D2.1 Ex-ante Cost-Benefit Analysis or WG1-ANNEX4-C-ITS or external sources such as related or past mobility projects such as Compass4D or FREILOT or academic studies on the expected effect of C-ITS services) to concretize these parameters / costs and benefits.

2.1. Stakeholder Types in C-ITS-enabled Mobility Solutions

A business model blueprint depicts the stakeholders that are involved in offering a solution including their contributions and the main cost and benefit that they are expected to incur. As large-scale deployments of C-ITS driven mobility solutions require multitude of stakeholders to closely collaborate, it is important to have a joint view on the categories of stakeholders that should be considered in the design of these solutions.

The *broad* types of stakeholders that we have identified and that we consider to play critical roles in the deployment of mobility solutions in urban areas include the following:

- *Governmental/Public Bodies*: Local authorities, public road operators/traffic authorities, public transport operators, public emergency services, and others as such.
- *Citizens*: Travellers including drivers, pedestrians, cyclists, and physically challenged/disabled road users, mobility service users (e.g., public transport user), and other citizens of such.
- *Businesses/Operators*: Transport (& logistics) operators, mobility service providers (including vehicle rental/sharing, parking, maps, navigation & data, mobile network operators), technology providers (OEM, software, etc.), private emergency services and operators, and other businesses as such.
- *Other Service Providers*: Insurance companies, retailers, media and leisure/entertainment services, engineers/contractors, and other providers as such.
- *Policy Advisors/Communities/Innovation Agencies/Research Agencies*: Public-private partnerships, NGOs, associations (cyclists, motorist, automobile clubs, forums, etc.), trade bodies, licensing and legislators, incubators, and research institutes & universities.

Majority of the stakeholders that are depicted in the blueprints that are presented in this document can be mapped to one of these categories of stakeholders.

3. Consolidated Set of Business Model Blueprints

In the following subsections, we list the business model blueprints that were consolidated from the blueprints developed in collaboration with relevant stakeholders at the C-MobILE deployment sites. We also list the C-ITS Services that each blueprint incorporates to give a better insight into the service solution. Next, we describe each blueprint in detail per chapter.

In presenting each blueprint, first we briefly introduce the mobility challenge that the business model aims to address. After referring to the C-ITS service(s) involved in the mobility solution, we describe the business model including the SDBM/R that reflects the blueprint design. Additionally, we focus our attention on the actors involved in the model and their cost/benefit structure. Finally, we present the operational and the value-capture scenarios of the main business model. For some blueprints, we also present potential variants that can be implemented as alternatives.

Table 1: List of C-MobILE Business Model Blueprints wrt. C-ITS Services

C-ITS Services → Business Models ↓	Urban Parking Availability	Road Works Warning	Road Hazard Warning	Emergency Vehicle Warning	Signal Violation Warning	Warning System For Pedestrian	Green Priority	GLOSA	Cooperative Traffic Light For VRU	Flexible Infrastructure	In-vehicle Signage	Mode & Trip Time Advice	Probe Vehicle Data	Emergency Brake Light	Coop. (Adaptive) Cruise Control	Slow or Stationary Vehicle Warning	Motorcycle Approaching Indic.	Blind Spot Detection/ Warning
Business Model Blueprints	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18
BM01 – Decreased Truck Traffic Through Inner City							X	X										
BM02 – Comfortable Commuting by Bike									X									
BM03 – More Efficient Fleet Operation								X										
BM04 – Hassle-free Event Experience												X	X					
BM05 – Green and Comfortable Commuting to Inner City	X						X					X						
BM06 – Safe Driving Experience		X	X	X	X	X					X		X	X	X	X	X	X
BM07 – Reliable and Efficient Transport Operation		X	X				X	X		X	X		X			X		
BM08 – Efficient Delivery in Urban Area	X																	
BM09 – Faster and Safer Travel of Emergency Vehicles				X			X											
BM10 – Comfortable Walking									X									

4. BM01-Decreased Truck Traffic through Inner City

4.1. Description

One of the challenges that cities face is the truck traffic that goes through inner city to save time, rather than following the ring roads that are more suitable for such traffic. The through traffic causes inner cities to become quickly congested. Besides, the road maintenance increases as the infrastructure in inner cities are not always suitable for heavy freight logistics. As a result, cities prefer trucks to take the ring roads / alternate routes to avoid traffic, thereby decreasing cost of maintenance, noise, and pollution in the inner city. For truck drivers, however, taking different, less direct routes often means increased travel time and distance. Given this challenge of the conflicting perspectives, a solution should be established in which truck drivers are stimulated to take the ring roads / alternative routes, satisfying the needs of both the logistic companies and the city.

The solution involves the deployment of a number of technology services that offer priority and comfort to truck drivers when taking the ring roads. In particular, it involves the *green priority (Section 19.7)* and *green light optimal speed advice - GLOSA (Section 19.8)* services. The green priority service aims to change the traffic signal status in the path of designated vehicles – in this case trucks– to help reduce their travel time. GLOSA service provides drivers a speed advice when they approach to a signalized intersection. This advice may involve maintaining actual speed, slowing down, or adapting a specific speed, and time-to-green information when the vehicle is stopped in the light.

Using these technologies in the ring roads allows designated trucks (e.g., of a logistic company/fleet operator) to increase their throughput similar to taking the inner-city roads, hence reducing the number of trucks that venture into the inner city. Moreover, as variations in speed are reduced, the logistic company/fleet owner may also benefit from reduced fuel consumption.

The business model blueprint for a potential solution is depicted in Figure 2.

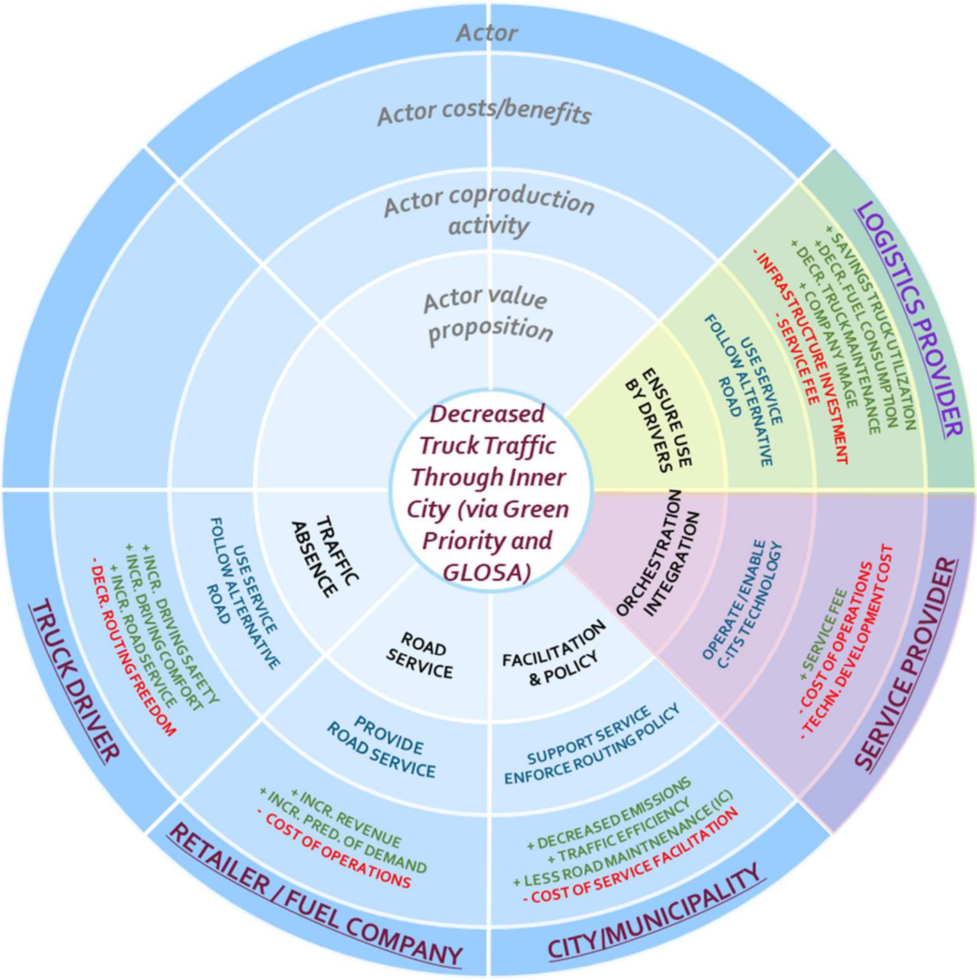

Figure 2: Business model radar for BM01-Decreased Truck Traffic through Inner City

4.2. Involved Actors

Logistics provider (customer)

The logistics provider wishes to stimulate its drivers to follow the ring roads to gain priority for its trucks on the same ring roads and cut off the fuel costs occurring from extra time spent in city traffic. Accordingly, the logistics provider's value proposition is to ensure *the use of service* by its truck drivers. By ensuring the use of service, the logistics provider benefits from increased *company image*, *decreased fuel consumption, improved truck utilization* and *reduced maintenance costs*. In return, the logistics provider bears the cost of *on-board units (OBUs)*, as well as pays a *service fee* for its drivers to use the service.

Service provider (orchestrator)

The service provider develops and enables the service, allowing logistics companies to achieve the same throughput when taking the ring road as compared to venturing in the inner city. Therefore, the value proposition of the service provider to *ensure* higher throughput for truck companies on the ring roads. As coproduction activity, the service provider operates and enables the C-ITS infrastructure to ensure the higher throughput. The service provider benefits from *a service fee* paid to activate and using the service (by the logistics provider), whereas *operational and technical development costs* are incurred to manage and maintain the C-ITS infrastructure and service.

Municipality (core partner)

The city / municipality benefits from *reduced numbers of trucks within the inner city* representing the citizens. Consequently, this would lead to a variety of *environmental, social and financial* benefits for the city. For the service to be used, it should ensure that relevant policies are enforced, which would allow trucks (participating in the scenario) to receive priority when taking the ring roads / alternative routes. Therefore, the value proposition of the city municipality is the *truck routing policy* which would allow trucks (participating in the scenario) to receive priority when taking the ring roads. Furthermore, the city / municipality sponsors the traffic manager for operating and enabling the service (in the form of *service fee* and *infrastructure costs*) who benefits from the revenues accrued of offering the service.

Retailer / Fuel company (enriching partner)

Leading truck drivers to ring roads can result in increased revenues for the retailer / fuel companies situated on the ring roads. Therefore, the value proposition of retailers is to provide ring road services to the truck drivers. Retailers / fuel companies will benefit from increased (attention of) truck drivers, whom moreover can spend more. The increased revenues can be invested in betterment of the ring road services and increased operational costs. Specifically, retailers can offer fuel discounts to further stimulate logistics providers / truck drivers to take the alternative route.

Truck driver (core partner)

The truck driver can use the service (through on-board unit or a smart device app) to receive advice and guidance on ring roads to take. The feasibility of the value in use offered through the business model depends on the adoption of the service and the behaviour of the truck driver whilst using the service. Therefore, the value proposition of the car commuter is the use of the service. If truck drivers are not stimulated to take the ring roads, the value in use decreases. The car commuter will benefit from an increased driving safety, driving comfort and variety of the ring road services. To use the service, the truck driver is bounded to take ring roads, which may impact his or her routing freedom.

4.3. Operational Scenario

The business model is orchestrated by a service provider that takes care of developing and enabling the service, allowing logistics companies to achieve the same throughput when taking the ring road as compared to venturing in the inner city. The customer of the business model is the city (or municipality), which benefits from reduced numbers of trucks within the inner city representing the citizens. Consequently, this would lead to a variety of environmental, social, and financial benefits for the city. For the service to be used, it should ensure that relevant policies are enforced, which would allow trucks (participating in the scenario) to receive priority when taking the ring roads. The city sponsors the service provider for operating and enabling the service, who benefits from the revenues accrued of offering the service. The business model can be enhanced by fuel companies (or retailers) positioned on the ring roads. Such partners might also benefit from increased revenues and increased predictability of demand, as truck drivers are stimulated to take the ring roads instead. The operational scenario for BM01 is illustrated, using choreography diagrams to demonstrate the flow of operations, in Figure 3.

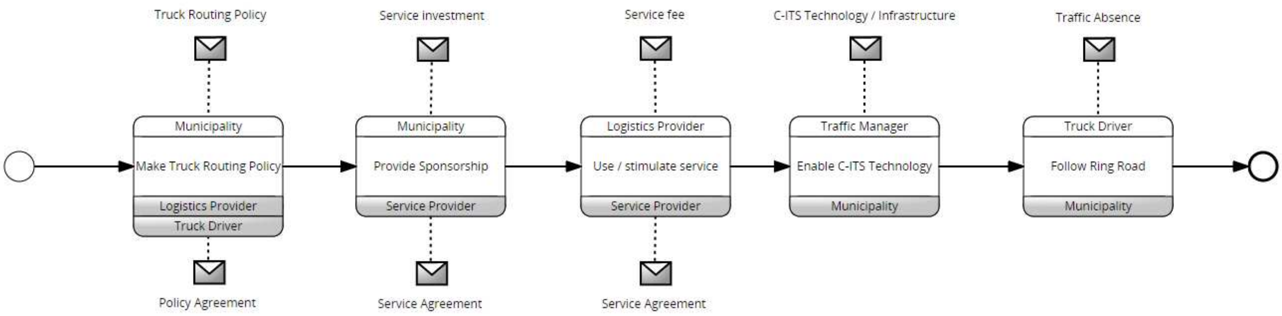

Figure 3: Choreography diagram for BM01 – Decreased Truck Traffic Through Inner City

4.4. BM01 Business Case Analysis

BM01 consists of 5 actors, of which 4 (namely the city, service provider, logistics provider and retailer) generate tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the truck driver solely generates intangible costs and benefits (e.g., largely related to perceptions and difficult to quantify or express in financial terms). As we focus on the financial viability of the business model design, we do not include intangible costs and benefits, as quantifying such costs and benefits requires us to build on a significant set of assumptions, reducing the overall accuracy of the analysis and increased its complexity. As a result, the perspective of the truck driver is not considered for further calculations, whereas we assume that the truck driver is incentivized or stimulated by the logistics provider to use the service. However, note that intangible benefits should not be neglected, as the use of the service is key for the viability of the business model design. In addition, we ignore any remaining intangible benefits for the other actors. For example, increased (company) image is ignored as it is intangible (based on perceptions) and would moreover require significant assumptions to cover all direct and indirect effects that may pertain to image. Again, such benefits should be considered next to the financial performance of the actor in the business model design.

For the business case analysis, we first capture what financial transactions are made between actors in the business model design. Leveraging the value capture diagrams presented in Figure 4, we observe that the main transaction involves a *service fee* paid by the logistics provider to the service provider. As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that each of the actors also generate costs and benefits which are not based on exchange and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions, traffic efficiency and fuel consumption). These costs and benefits logically are considered for conducting the business case analysis.

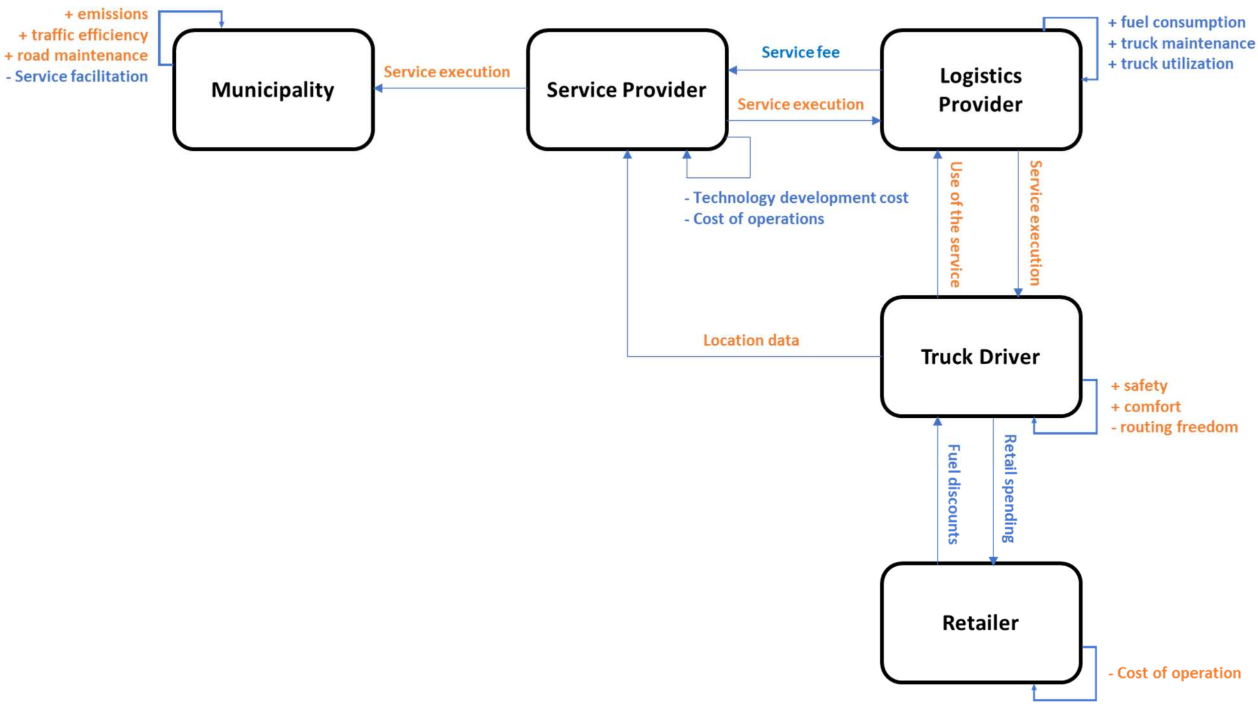

Figure 4: Value capture diagram for BM01-Decreased Truck Traffic through Inner City

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. For this analysis, the parameter values as listed in Table 2 have been used. These values are based on the deployments in *Helmond, the Netherlands* (North Brabant deployment site) where applicable. Per actor, we discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 2: Parameter settings for BM01 business case analysis

Parameter description	Frequency	Value
Average amount of trucks using the service	Fixed	100 trucks
Average amount of trucks compliant to service policy	Fixed	100%
Decrease in fuel consumption as a result of using the service	Per intersection	0,7 liter[1,2]
Number of intersections equipped	Fixed	15[3]
Average waiting time at an intersection	Fixed	1 minute
Average revenue generated per truck	Per week	3135,63 euro[4]
Average amount of working hours per truck	Per month	240 hours[5]
Frequency of a truck passing the service supported trajectory	Per month	25 times
Purchase price of OBU (for the logistics provider)	Fixed	1200 euro[3]
Service fee (paid by the logistics provider to the service provider)	Per month	70 euro
Development cost per OBU	Fixed	500 euro[3]
Maintenance cost per OBU	Fixed	20 euro
Development cost per RSU	Fixed	1500 euro[3]

[1] https://www.verizonconnect.com/resources/article/engine-idling/#:~:text=According%20to%20the%20Department%20of,of%20fuel%20while%20they%20sleep.
[2] *Jinghui Wang, Hesham A. Rakha (2017) Fuel consumption model for heavy duty diesel trucks: Model development and testing. Transportation Research Part D 55 (2017) 127–141*
[3] *Information obtained through Video-Conference Helmond [03-02-2021]*
[4] *https://www.freightwaves.com/news/why-net-revenue-per-truck-per-week-is-a-key-metric, average between 2800$ and 4800$ for normal truck loads*
[5] *Considering a 60 hour work week*

Maintenance cost per RSU	Fixed	100 euro
Amount of RSUs equipped	Per intersection	3 units[3]
Fuel price	Fixed	1,73 euro[6]
Discount on fuel offered by retailer	Fixed	10%
Increase in fuel purchase at retailer for trucks using the service	Fixed	50%
Average increase in retail spending per truck	Fixed	15%
Average emissions of tCO_2 per liter of diesel	Fixed	0,00264 ton[7]
Monetary value of 1 tCO_2	Fixed	84,00 euro[8]
Percentage decrease in maintenance per truck as a result of using the service	Fixed	1%
Average maintenance costs per truck	Per month	1000 euro[9]
Decrease in road maintenance cost per absence of a single truck	Per year / per mile	3,12 euro[10]
Amount of road users (Helmond)	Per month	10.000 users
Amount of kilometers road in the inner city avoided through service use	Fixed	10 km
Cost of facilitation of service operations	Per month	1000 euro[3]

4.4.1. Logistics Provider

The detailed tab of the logistics provider is illustrated in Figure 5 (presenting the costs and the left and the benefits on the right). For this business case, we assume that 100 trucks on average use the service (note that such values can be freely changed to explore different scenarios). The financial costs illustrated for the business model design, namely the investments in infrastructure (related to the acquisition of OBUs) and the infrastructure fee are dependent on the amount of trucks active. Assuming a price for OBUs to deploy *green priority / GLOSA* of €1000 and a service fee of €70,00 per month, this would yield a fixed one-time cost of €120.000 in year one with respect to infrastructure investments, and a €84.000 yearly cost in terms of using the OBUs.

[6] *https://www.anwb.nl/vakantie/reisvoorbereiding/euro-95-benzineprijzen-europa - The Netherlands [29-04-2021]*
[7] *https://ecoscore.be/en/info/ecoscore/co2*
[8] *https://www.en-former.com/en/metric-ton-co2-cost/*
[9] *https://missionfinancialservices.net/what-are-your-options-to-cover-the-cost-of-semi-truck-repair/#:~:text=Most%20importantly%2C%20year%20truck%20maintenance,tires%20on%20an%2018%20wheeler.*
[10] *http://onlinepubs.trb.org/Onlinepubs/trr/1990/1262/1262-006.pdf*

	Value	Frequency	Yearly frequency
Investments in infrastructure	**€ 120.000,00**	**fixed**	**€ 120.000,00**
Amount of trucks to be equipped	100	fixed	
Price per OBU	€ 1.200,00	fixed	
	Value	Frequency	Yearly frequency
Service fee	**€ 7.000,00**	**per month**	**€ 84.000,00**
Amount of trucks to be equipped	100	fixed	
Service fee	€ 70,00	per month	

	Value	Frequency	Yearly frequency
Expenditure decrease in fuel consumption	**€ 45.412,50**	**per month**	**€ 544.950,00**
Number of trucks using service	100	fixed	
Number of trucks equipped with service	100	fixed	
Fraction of trucks compliant to service	100%	fixed	
Fuel saved through use of service	10,5	fixed	
Decrease in fuel consumption as a result of not stopping	0,7	fixed	
Number of intersections	15	fixed	
Frequency of truck passing service supported trajectory	25	per month	
Fuel price	€ 1,73	fixed	
Expenditure decrease in truck maintenance	**€ 1.050,00**	**per month**	**€ 12.600,00**
Number of trucks using service	100	fixed	
Number of trucks equipped with service	100	fixed	
Fraction of trucks compliant to service policy	100%	fixed	
Percentage decrease in maintenance per truck using service	1%	fixed	
	0,0007	fixed	
Amount of intersections equipped with service	15	fixed	
Average monthly maintenance costs per truck	€ 1.000,00	per month	
Monetary savings on truck utilization	**€ 5.661,55**	**per month**	**€ 67.938,65**
Number of trucks using service	100	fixed	
Number of trucks equipped with service	100	fixed	
Fraction of trucks compliant to service policy	100%	fixed	
Decrease in travel time (minutes)	15	fixed	
Average waiting time for a stop (minutes)	1	fixed	
Amount of intersections included	15	fixed	
Frequency of truck passing service supported trajectory	25	per month	
Value of a minute saved	€ 0,15	per month	
Average working hours per truck	60	fixed	
Average monthly revenue generated per truck	€ 3.135,63	per week	

Figure 5: Breakdown of the costs and benefits for the Logistics Provider

For the benefits, we require to quantify the decrease in fuel consumption, the decrease in truck maintenance and the savings on truck utilization in financial terms. Assuming that on average, a truck passes the service supported trajectory 25 times per month, assuming that per instance 10,5 litres of fuel consumption can be saved through the use of the service if 15 intersections are outfitted to accommodate the service (referring to the ex-ante analysis as per D2.1), and assuming on average the fuel price is €1,73[6], use of the service would amount to yearly saved expenditures of €544.950,00. Similarly, a decrease in truck maintenance expenditures of €12.600 is achieved, under the conditions that the average monthly maintenance costs amount to €1000, whereas use of the service may generate a 1% decrease for these costs. Lastly, spending on truck utilization can be decreased by €67.938,65, assuming that a truck on average generates a revenue of €3.135,63 per week[4], whereas as a result of service use (assuming an average waiting time at a stop of 1 minute), 15 minutes can be saved.

4.4.2. City / Municipality

The detailed tab of the city / municipality is illustrated in Figure 6 (presenting the costs and the left and the benefits on the right). One can see that the costs for the municipality pertain to the facilitation of the service deployment and operation, sustaining the provisioning of the service (currently set at a monthly expense of €1000). In terms of benefits, as per the business model design, the decrease in emissions, decrease in expenditure of road maintenance and increase in traffic efficiency should be considered. For emissions, we consider that the use of green priority under the current number of intersections would decrease fuel consumption by 10,5 liters per trajectory crossing (assuming 25 crossings per month). Leveraging a value of €84 per metric ton of CO_2 produced[11], and assuming on average a liter of fuel consumption generates 0,00264 ton of CO_2, this would yield a yearly €69.854,40 worth of decreased emissions. With respect to road maintenance, if the impact of truck on road maintenance amounts to $3,73 or €3,12, and that an area of 10 kilometers in the inner city is avoided through use of the service, yearly savings of €5032,26 can be generated with respect to road maintenance for the inner city. Lastly, with regards to traffic efficiency, assuming that on average a road user in Helmond wastes 1 minute per month in the inner city as a result of trucks, and assuming that 10.000 road users on average are active in Helmond and a monetary time value of €0,26 per minute saved, use of the service would yield a monetary value of €31.250 yearly with respect to traffic efficiency.

[11] https://www.en-former.com/en/metric-ton-co2-cost/

	Value	Frequency	Yearly frequency
facilitation of service operations	**€ 1.000,00**	**per month**	**€ 12.000,00**
Facilitation of service operations	€ 1.000,00	per month	

	Value	Frequency	Yearly frequency
Monetary value of decreased emissions	**€ 5.821,20**	**per month**	**€ 69.854,40**
Fuel saved through use of service	10,5	fixed	
Decrease in fuel consumption as a result of not stopping	0,7	fixed	
Number of intersections	15	fixed	
Monetary value of CO2/L per diesel emission	€ 0,22	fixed	
Average emissions of tCO2 per litre diesel	0,00264	fixed	
Monetary value of 1 tCO2	€ 84,00	fixed	
Number of trucks using service	100	fixed	
Number of trucks equipped with service	100	fixed	
Fraction of trucks compliant to service policy	100%	fixed	
Frequency of truck passing service supported trajectory	25	per month	

	Value	Frequency	Yearly frequency
Expenditure decrease road maintenance	**€ 5.032,26**	**per year**	**€ 5.032,26**
Number of trucks using service	100	fixed	
Number of trucks equipped with service	100	fixed	
Fraction of trucks compliant to service policy	100%	fixed	
Decrease in expenditure road maintenance per truck	€ 50,32	per year	
Decrease in expenditure road maintenance per year / per mile	€ 3,12	per year	
Amount of kilometers road avoided by trucks	10	fixed	

	Value	Frequency	Yearly frequency
Increase in traffic efficiency	**€ 2.604,17**	**per month**	**€ 31.250,00**
Value of a minute saved	€ 0,26	fixed	
Average income	€ 2.500,00	per month	
Average amount of time saved	10000	per month	
Average stop time road users as a result of trucks	1	per month	
Amount of road users in Helmond	10000	fixed	

Figure 6: Breakdown of the costs and benefits for the City / Municipality

4.4.3. Retailer / Fuel Companies

The detailed tab of the retailer / fuel company is illustrated in Figure 7. One can see that as per incentivizing the logistics providers, discounts are offered to trucks using the service. These discounts represent the costs for the fuel companies / retailers. Assuming that a discount of 10% is offered to the trucks of a compliant logistics provider, this results in 50% of the trucks withdrawing fuel from the fuel company and assuming that trucks on average require 50 liters of fuel, this would yield a yearly cost of discounts of €5.010. In terms of benefits, the increased predictability of demand can be translated into increased revenue because of 50% of the truck drivers using the service now purchasing fuel from this respective fuel company. This would yield a yearly additional revenue of €45.000. In addition, the savings on fuel for logistics providers could spark truck drivers to increase their spending at fuel companies. Assuming that a 15% increase in spending can be generated, and that on average truckers spent a €100 per month on retail consumption, this would generate an additional yearly income of €9.000.

	Value	Frequency	Yearly frequency
Cost of fuel discounts	**€ 432,50**	**per month**	**€ 5.190,00**
Number of trucks using service to withdraw from retailer	50	per month	
Number of trucks equipped with service	100	fixed	
Fraction of trucks withdrawing from retailer	50%	fixed	
Decrease in revenue per litre	€ 0,17	fixed	
Price of fuel	€ 1,73	fixed	
Percentage decrease discount	10%	fixed	
Average fuel need for a truck (litres)	50	fixed	

	Value	Frequency	Yearly frequency
Increase in revenue fuel demand	**€ 4.325,00**	**per month**	**€ 51.900,00**
Number of trucks using service to withdraw from retailer	50	per month	
Number of trucks equipped with service	100	fixed	
Fraction of trucks withdrawing from retailer	50%	fixed	
Price of fuel	€ 1,73	fixed	
Average fuel need for a truck (litres)	50	fixed	

	Value	Frequency	Yearly frequency
Increase in expenditures retail	**€ 750,00**	**per month**	**€ 9.000,00**
Number of trucks using service to withdraw from retailer	50	per month	
Number of trucks equipped with service	100	fixed	
Fraction of trucks withdrawing from retailer	50%	fixed	
Monthly average retail spending	€ 100,00	per month	
Coefficient of increase in expenditure	€ 100,00	fixed	
Percentage increase expenditure at retailer	15%	fixed	
Coefficient of increase in expenditure (retail)	15%	fixed	

Figure 7: Breakdown of the costs and benefits for Retailer / Fuel Company

4.4.4. Service Provider

The detailed tab of the retailer / fuel company is illustrated in Figure 8. The costs for the service provider relate to the development and maintenance of the RSUs (to be deployed at the intersections to support *green priority*) and the development and maintenance for the OBUs to be installed in the trucks of the logistics provider. For the RSUs, assuming that 3 RSUs per intersection are needed and a total of 15 intersections are to be equipped, and further considering that the development and maintenance costs for a single RSU are €1500 (one time) and €100 (monthly) respectively, the costs for maintenance and development of RSUs would amount to €67,500 (one-time payment) and €54,000 (yearly) respectively. Similarly, for the OBUs, considering a development cost per OBU of €500 (one time), and a maintenance cost per OBU of €20 (monthly), this would yield yearly expenditures in terms of maintenance costs for OBUs amounting €24.000, as well as an upfront investment of €50.000 for the development of the OBUs. On the benefits side, the service provider receives from the logistics provider an infrastructure fee (to use the OBUs) as well as a one-time purchase price for selling the OBUs. The values here (€84.000 service fee and €10.000 infrastructure investment) correspond to the costs incurred by the logistics provider.

	Value	Frequency	Yearly frequency
Maintenance costs RSUs	**€ 4.500,00**	**per month**	**€ 54.000,00**
Maintenance costs per RSU	€ 100,00	per month	
Amount of RSUs per intersection	3	fixed	
Amount of intersections	15	fixed	

	Value	Frequency	Yearly frequency
Development costs RSUs	**€ 67.500,00**	**fixed**	**€ 67.500,00**
Development costs per RSU	1500	fixed	
Amount of RSUs per intersection	3	fixed	
Amount of intersections	15	fixed	

	Value	Frequency	Yearly frequency
Maintenance costs OBUs	**€ 2.000,00**	**per month**	**€ 24.000,00**
Maintenance costs per OBU	€ 20,00	per month	
Amount of trucks to be equipped	100	fixed	

	Value	Frequency	Yearly frequency
Development costs OBUs	**€ 50.000,00**	**fixed**	**€ 50.000,00**
Development costs per OBU	€ 500,00	fixed	
Amount of trucks to be equipped	100	fixed	

	Value	Frequency	Yearly frequency
Investment received infrastructure	**€ 10.000,00**	**fixed**	**€ 10.000,00**
Amount of trucks to be equipped	100	fixed	
Price per OBU	€ 100,00	fixed	

	Value	Frequency	Yearly frequency
Service fee	**€ 7.000,00**	**per month**	**€ 84.000,00**
Amount of trucks to be equipped	100	fixed	
Service fee	€ 70,00	per month	

Figure 8: Breakdown of the costs and benefits for Service Provider

4.4.5. Results of business case analysis

Based on the selected parameter settings, the business case results as presented in Figure 9 are obtained. One can see that based on these parameter settings, all actors for BM01 obtain a positive financial outcome. The logistics provider significantly benefits from the fuel saved because of the use of the service, which would be further stimulated in case more trucks would be equipped. Moreover, as stops are avoided and acceleration / deceleration is reduced, the logistics provider further benefits from decreased expenditures in truck maintenance and increased truck utilization (in this case amounting €12.600 and €67.938,65 respectively). For the city, the monetary savings on decreased emissions significantly outweigh the monthly service fee of €1000 paid to the service provider. In addition, the city benefits from savings in terms of decrease expenditures on road maintenance and the increased value of traffic efficiency. Although the retailer incentivizes the truck users to take the ring road through discounts on fuel (resulting in costs for the retailer as opposed to selling the at the regular tariff of €1.736), such discounts may sway the truck users to withdraw fuel at this respective fuel company / retailer (in this case assumed to be 50% of the trucks using the service). The resulting increase in demand offsets the discounts offered. Here, we can also expect truckers to also increase their spending at the fuel company / associated retailer.

It should be noted however that in this scenario, the initial investments for the service provider are significant (€107.500,000 due to the development costs with regards to the OBUs and RSUs). Under the current parameter settings for service fee (which as explained are determined by the stakeholders involved for the exchange), the payback period is significant (18 years). Altering the service fee from €70 to €100 (e.g., a €30 increase per truck to use the OBU), the logistics provider is still able to offset the costs generated through the significant benefits related to a decrease in fuel consumption. This does however enable the service provider to break-even in roughly 2 years. Note that a service fee of less than €65 would result in a loss for the service provider, rendering the scenario inviable.

Logistic Provider

Costs	value	frequency	Benefits	value	frequency
Investments in infrastructure	€ 120.000,00	fixed	Expenditure decrease in fuel consumption	€ 544.950,00	per year
Service fee	€ 84.000,00	per year	Expenditure decrease in truck maintenance	€ 12.600,00	per year
			Monetary savings on truck utilization	€ 67.938,65	per year
Total	€ 84.000,00		Total	€ 625.488,65	
Yearly balance	€ 541.488,65				
Fixed investments	€ 120.000,00				

Service Provider

Costs	value	frequency	Benefits	value	frequency
Maintenance costs RSUs	€ 54.000,00	per year	Investment received infrastructure	€ 10.000,00	fixed
Development costs RSUs	€ 67.500,00	fixed	Service fee	€ 84.000,00	per year
Maintenance costs OBUs	€ 24.000,00	per year			
Development costs OBUs	€ 50.000,00	fixed			
Total	€ 78.000,00		Total	€ 84.000,00	
Yearly balance	€ 6.000,00				
Fixed investments	€ 107.500,00				

City

Costs	value	frequency	Benefits	value	frequency
Facilitation of service operations	€ 12.000,00	per year	Monetary value of decreased emissions	€ 69.854,40	per year
			Expenditure decrease road maintenance	€ 5.032,26	per year
			Increase in traffic efficiency	€ 31.250,00	per year
Total	€ 12.000,00		Total	€ 106.136,66	
Yearly balance	€ 94.136,66				
Fixed investments	0				

Retailer

Costs	value	frequency	Benefits	value	frequency
Cost of fuel discounts	€ 5.190,00	per year	Increase in revenue fuel demand	€ 51.900,00	per year
			Increase in expenditures retail	€ 9.000,00	per year
Total	€ 5.190,00		Total	€ 60.900,00	
Yearly balance	€ 55.710,00				
Fixed investments	€ -				

Figure 9: Financial dashboard for BM01

5. BM02-Comfortable Commuting by Bike

5.1. Description

Reducing car traffic in certain urban regions is among the common objectives of many mobility initiatives. In this business model scenario, an employer (an organization or and industrial zone) aims to endorse or stimulate cycling as the mode of commuting for its employees. This is with the aim to reduce traffic in the vicinity of the business premises, and to reduce the need for parking spaces for private cars on location. To foster this, a service provider offers priority crossing for cyclists via a smart device application (through the service of "cooperative traffic light for VRUs" as described in Section 19.9), which can be activated via software codes. These codes are purchased by the employer, which distributes these codes to its employees commuting by bike. The service can be adapted or customized to fit the needs of the user or the environment (i.e., activating only during rush hours).

The value proposition of this business model is comfortable commuting by bike to employees who commute (or will commute) by bike. The comfort implies that the cyclist can maintain a regular speed or flow whilst cycling and is either interrupted less frequently at intersections or can more quickly continue his or her journey after a stop.

The business model blueprint for a potential solution is depicted in Figure 10.

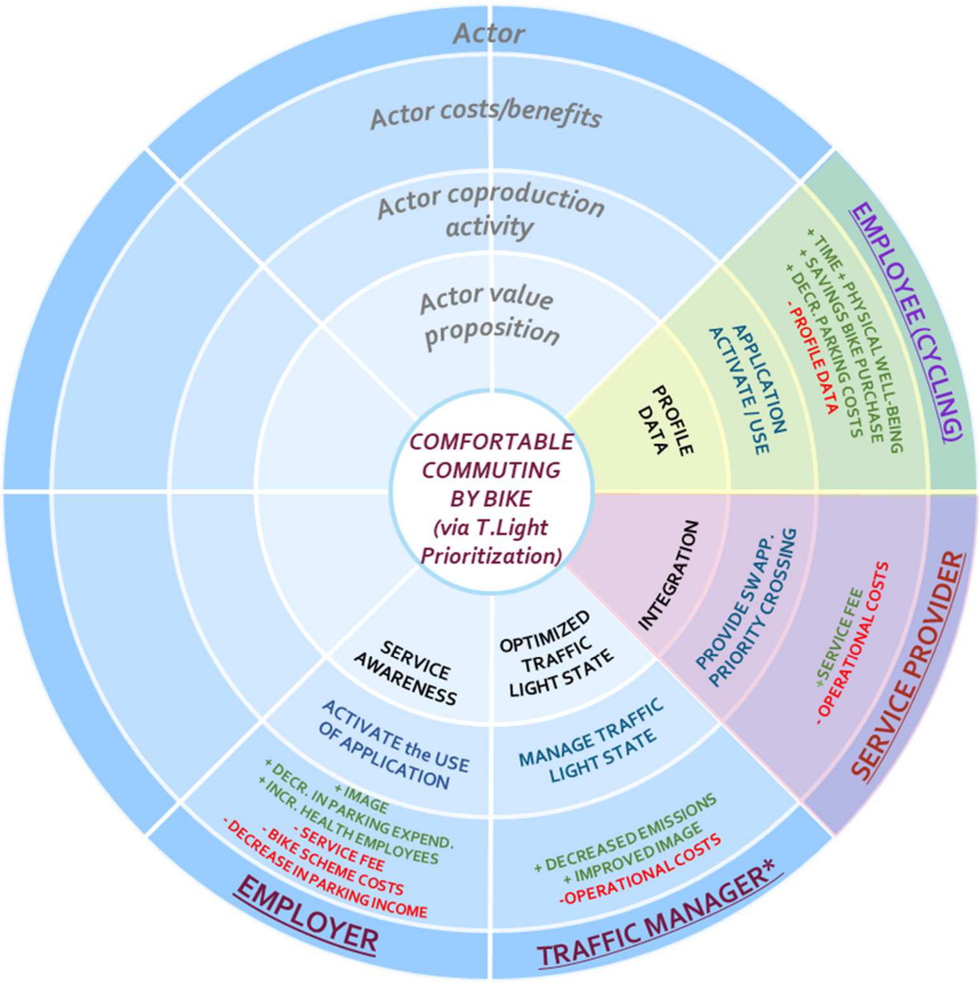

Figure 10: Business model radar for BM02- Comfortable Commuting by Bike

5.2. Involved Actors

Employee (customer)

The employee (cyclist) uses the code to activate the application, which runs in the background and interacts with traffic lights (and associated systems at intersections). The application tracks the location and direction of the employee and integrates this data with traffic light state information to provide traffic light prioritisation to cyclists. This service can be customized or adapted based on the user's characteristics or profile (i.e., handicapped, or elderly user). Therefore, the value proposition of the employee is to provide (profile) data, which is generated through the coproduction activity of activating and using the software application. The employee benefits from shorter travelling and increased comfort, as stops at traffic lights are decreased or even avoided. Moreover, employees may also benefit from increased physical well-being as a more stable and regular flow and speed can be maintained whereas stress can be largely avoided whilst cycling. In addition, as use of the service drives a portion of employees to travel by bike (rather than car), a decrease in parking costs can be expected. To stimulate adoption of the service, the employer may also offer discounts on bike purchase schemes to its employees. In such cases, the employee also benefits from savings with regards to a bike purchase. As a cost, the employee must provide profile and/or location data, particularly if the service should be customized to the user's needs.

Service provider (orchestrator)

The service provider provides traffic light prioritisation to its users. The service depends on integrating floating cyclist data with traffic light state data to provide priority to approaching cyclists at a specific traffic light. This data is consequently forwarded to the traffic manager. Therefore, the value proposition of the service provider is to *integrate* both sources of data to provide the service to the employee. As coproduction activity, the service provider provides the software application to operate the service and integrate both streams of data. The service provider benefits from *service fees* paid to activate and using the service, whereas *operational costs* are incurred to manage and maintain the software application and service.

Traffic manager (core partner)

The traffic manager (or in case integrated, *the municipality*) is responsible for managing the traffic lights and providing optimized traffic light states for cyclists using the service application. Based on the integrated data received from the service provider, the traffic manager warrants either priority to additional crossing time at traffic lights (i.e., either faster time to green or extended green). Therefore, the value proposition of the traffic manager is to offer *optimized traffic light states*, which is offered through the coproduction activity of *managing traffic light states*. The traffic manager benefits from a more *eco-friendly* or *green image*, as the business model stimulates commuting by bicycle instead of car. Moreover, as priority is given to cyclists, a *less stressful and safer experience to cyclists* can be offered, whereas accidents can be avoided. In turn, this should further benefit the traffic *image*.

Employer (core partner)

The employer wishes to stimulate its employees to commute by bike. The role of the employer is to distribute the service through buying and offering the codes to its employees. Therefore, the value proposition of the employer is *the distribution of the service*. The employer does so through the coproduction activity of *promoting the use of the application*, which incorporates financing the codes, distributing the codes of employees who commute or will commute by bike and further promoting the service. The employer will benefit from *less traffic in less premises of the business area*, as use of the car is avoided. Moreover, this will also result in *a decreased need for parking spaces on-site*. As a cost, the employer will pay a service fee per employee to the service provider.

5.3. Operational scenario

To operate the solution, the data concerning the location and travel direction of the user (i.e., commuting cyclist) is collected through the smartphone application. The application runs in the background; as such, no interference of the cyclist is needed. Moreover, traffic lights are equipped with the technology to allow software application on cyclist's smart device to interact with the lights. Once the cyclist (carrying a smart device with active application) approaches the traffic light, two scenarios occur. In case of a red light, increased priority is given to the VRU by activating the green light quickly and allowing the cyclist to continue with reduced waiting time. In case of a green light, the duration is extended to support the flow. The service can be catered to the needs or characteristics of the user or can be altered for special conditions (such as the weather).

The operational scenario is depicted in the form of a choreography diagram in Figure 11. (Appendix-C describes how a choreography diagram can be interpreted.)

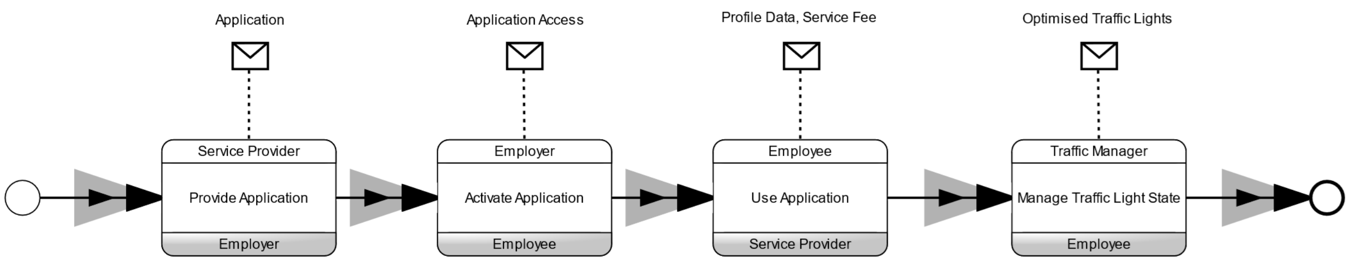

Figure 11: Choreography diagram for BM02- Comfortable Commuting by Bike

5.4. BM02 Business Case Analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM02 is depicted by means of the value capture diagram presented in Figure 12. As can be seen, BM02 consists of 4 actors, of which 3 (namely the service provider, traffic manager and employer) generate financial or tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the employee generates, although benefiting from decreased parking costs and a discount on bike purchase schemes, predominantly intangible benefits (and does not partake in the exchange of financial value). Accordingly, we omit the perspective of the employee for the financial analysis of the business case for the business model design and focus on the remaining 3 parties.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that employer pays a *service fee* to the service provider such that its employees can use the service. In addition, as mentioned, the employer can further incentivize the use of the service, compensating a percentage of the bike purchase of employees that use the service. As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that most of the actors also generate costs and benefits which are not based on exchange and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions and well-being).

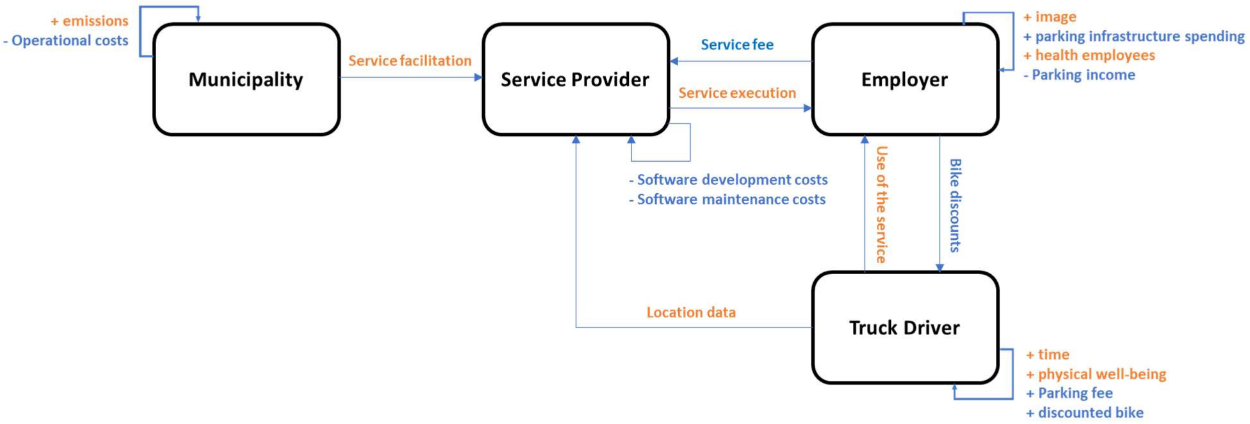

Figure 12: Value capture diagram for BM02 – Comfortable Commuting by Bike

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 4) have been used. These values are based on the deployments in *Eindhoven, Netherlands* (North Brabant site) where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 3: Parameter settings used for BM02 business case analysis

Parameter description	Frequency	Value
Number of service users	Per month	250 users
Service fee (paid by the employer to the service provider)	Per user	10 euro
Cost of software platform development	Fixed	1000 euro[12]
Cost of software platform maintenance	Per month	100 euro[12]
Number of intersections	Fixed	10[12]
Number of traffic lights	Per intersection	2 lights[12]
Infrastructure development cost	Per traffic light	1000 euro[12]

[12] *Information received through Video-Conference – Eindhoven [22-03-2021]*

Parameter description	Frequency	Value
Infrastructure maintenance cost	Per traffic light	100 euro[12]
Percentage of service users that shift from car to bike	Fixed	10%
Average number of trips per user	Per month	40 trips
Average commute distance	Per trip	20 km
Average fuel consumption	Fixed	0,073 L/km[13]
Average CO_2 emissions per liter of fuel consumption	Fixed	0,0264 tCO2[14]
Monetary value of 1 tCO_2	Fixed	84,00 euro[15]
Development cost of parking space infrastructure	Fixed	14.391 euro[16]
Average use of a parking space	Fixed	20%
Expected health effect of cycling to work	Fixed	46%[17]
Average expenditure on health benefits employer	Per year	1000 euro[18]
Percentage compensation offered on bike purchase	Fixed	25%
Average cost of a bike	Fixed	914 euro[19]
Cost of on-site parking	Per month	50 euro[20]

5.4.1. Service Provider

The detailed tab of the service provider is presented in Figure 13 (presenting the costs on the left and the benefits to the right). One can see that the costs for the service provider relate to the development and maintenance of the software platform and application used to operate the service. Here, a fixed, up-front development cost of €1.000 is selected, whereas the monthly maintenance costs for the software platform are set to €100 (per month). Accordingly, in addition to the fixed expenses at the start of the business model, the service provider incurs a yearly cost of €1.200. On the benefits side, one can see that the service provider receives a service fee (offered by the employer) to compensate for the costs incurred. For this scenario, the number of users (e.g., employees) is set to 250, whereas a €10 fee is charged per user for service usage. As a result, the monthly service fee received equals €2.500 or €30.000 yearly respectively (more than enough to outweigh the costs incurred).

		variable	fixed			
Cost of software platform		€ -	€ 1.000,00			
				frequency	value	yearly value
cost of software platform development				fixed	€ 1.000,00	€ 1.000,00
	Development cost			fixed	€ 1.000,00	
		variable	fixed			
Software platform maintenance		€ 1.200,00				
				frequency	value	yearly value
Software platform maintenance				per month	€ 100,00	€ 1.200,00
	Monthly maintenance cost			per month	€ 100,00	

		Variable	fixed			
Service fee		€ 30.000,00				
				frequency	value	yearly value
Service fee				per month	€ 2.500,00	€ 30.000,00
	Number of users			per month	250	
	Service fee (per user)			per month	€ 10,00	

Figure 13: Breakdown of the costs and benefits for the Service Provider

5.4.2. Traffic Manager

The detailed tab of the traffic manager is illustrated in Figure 14. The costs for the traffic manager constitute the development / purchase of traffic light infrastructure to support the operation of the service as well as the subsequent maintenance of this infrastructure. For the Eindhoven case, 10 intersections are considered, for

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13 https://www.osti.gov/pages/servlets/purl/1339511#:~:text=The%20average%20fuel%20consumption%20is,regulation%20(EU%2C%202009), an average consumption of 7.32 litres per 100 km

14 https://ecoscore.be/en/info/ecoscore/co2

15 https://www.en-former.com/en/metric-ton-co2-cost/

16 https://www.chapman.edu/campus-services/sustainability/_files/environmental-audit/photos-2017/Transportation-ch6-2017.pdf

17 https://www.cyclinguk.org/article/20-reasons-cycle-work

18 https://www.kff.org/health-costs/report/2020-employer-health-benefits-survey/, with employers covering $15754 per year [30-03-2021]

19 https://www.statista.com/statistics/395884/bicycle-average-prices-in-the-european-union-eu-by-country/#:~:text=The%20highest%20average%20price%20for,euro%20per%20bicycle%20on%20average. [29-04-2021]

20 https://www.tue.nl/en/our-university/departments/chemical-engineering-and-chemistry/the-department/how-to-reach-us/accessibility-tue-campus/accessibility-route-and-map-tue-campus/on-tue-campus/parking-on-tue-campus/parking-for-users-of-the-campus/charges-and-payment/ , considering 25 work days per month [29-04-2021]

which each intersection on average contains two traffic lights to be outfitted. For this scenario, the development and costs and maintenance costs for outfitting the traffic lights is set to €1.000 and €100 respectively, amounting a fixed infrastructure development cost of €20.000 and a yearly cost of infrastructure maintenance of €24.000.

		variable	fixed	frequency	value	yearly value
Cost of infrastructure development		€ -	€ 20.000,00			
				frequency	value	yearly value
Cos of traffic light infrastructure development				fixed	€ 20.000,00	€ 20.000,00
	Number of intersections			fixed	€ 10,00	
	Number of traffic lights per intersection			fixed	2	
	Cost per traffic light				€ 1.000,00	

		variable	fixed	frequency	value	yearly value
Cost of infrastructure maintenance		€ 24.000,00				
				frequency	value	yearly value
Cos of traffic light infrastructure development				per month	€ 2.000,00	€ 24.000,00
	Number of intersections			fixed	€ 10,00	
	Number of traffic lights per intersection			fixed	2	
	Cost per traffic light			per month	€ 100,00	

		Variable	fixed	frequency	value	yearly value
Value of decreased pollution		€ 44.352,00				
				frequency	value	yearly value
Value of decreased pollution				per month	€ 3.696,00	€ 44.352,00
	Number of service users			per month	250	
	Percentage of service users modal shift			fixed	10%	
	Number of trips per user			per month	40	
	Average commute to work			fixed	20	
	Average fuel consumption			fixed	0,083	
	Average emissions per litre consumed			fixed	0,0264	
	Monetary value of a ton CO2			fixed	€ 84,00	

Figure 14: Breakdown of the costs and benefits for the Traffic Manager

For the benefits, the value of the reduction of pollution is considered as users (employees) are stimulated through use of the service to shift their mode of transportation from car to bike, in turn resulting in decreased emissions. Accordingly, the value of decreased pollution is related to the amount of service users (previously indicated to be 250), for which we assume that 10% of these users actually conduct modal shift (e.g., 25 users would shift from car to bike, complemented by modes of transport such as train or bus). Per user, we set the average number of monthly trips (e.g., driving to or back from work) to 40 trips, whereas on average a trip amounts to 20 kilometers. Furthermore, the average fuel consumption per user is assumed to be 12 kilometers per liter or 0,083 liters per kilometer respectively. Considering CO_2 emissions to be 0,00264 tCO_2/L[21] and a monetary value of a tCO_2 of €84,00[22], the resulting value of decreased pollution would amount to €44.352 yearly as a benefit for the traffic manager. Note that a user base of less than 135 would not facilitate the traffic manager to compensate the variable costs incurred, thus rendering the business model financially inviable for the traffic manager.

5.4.3. Employer

The detailed tab of the employer is illustrated in Figure 15. One can see that the service fee indicated as a benefit for the service provider is represented as a cost for the employer. Note that in this scenario, a *single* employer is considered (as a representative of the user base). In case multiple employers are included in the business model design, the resulting costs and benefits should be divided accordingly. In addition to the service fee, the employer incurs costs related to stimulating the bike purchase scheme (to further support service usage) and the decrease in parking income. Assuming that the cost of a bike on average is €914,00[19] and that 25% of compensation is offered for service users, the fixed costs of the bike scheme amount to €25.000. Note that a variable cost of the bike scheme could be considered here as well in case a long-term perspective is considered (for example, employees are able to renew their bike after 5 years). In such cases, the average bike cost should be considered on a yearly basis. Lastly, with regards to the decrease in parking costs, taking into account the number of users that conduct modal shift (10%), and assuming that on average the parking fee amounts to €50,00 per month, the lost income in terms of parking fees amounts to €15.000 on a yearly basis.

		Variable	fixed	frequency	value	yearly value
Service fee		€ 3.000,00				
				frequency	value	yearly value
Service fee				per month	€ 250,00	€ 3.000,00
	Number of users			per month	250	
	Service fee (per user)			Fixed	€ 1,00	

		Variable	fixed	frequency	value	yearly value
Cost of bike scheme			€ 45.700,00			
				frequency	value	yearly value
Cost of bike scheme				fixed	€ 45.700,00	€ 45.700,00
	Number of users			fixed	914	
	Percentage of compensation offered			Fixed	25%	
	Average bike cost			Fixed	€ 200,00	

		Variable	fixed	frequency	value	yearly value
Decrease in parking income		€ 15.000,00				
				frequency	value	yearly value
Service fee				per month	€ 1.250,00	€ 15.000,00
	Number of users			per month	250	
	Percentage of service users modal shift			Fixed	10%	
	parking fee			per month	€ 50,00	

		Variable	fixed	frequency	value	yearly value
Decreased in parking expenditure			€ 71.955,00			
				frequency	value	yearly value
Decrease in parking expenditure				fixed	€ 71.955,00	€ 71.955,00
	Number of service users			per year	250	
	Percentage of service users modal shift			fixed	10%	
	Cost of infrastructure per parking space			fixed	€ 14.391,00	
	Average use of a parking space			fixed	20%	

		Variable	fixed	frequency	value	yearly value
Health benefits employees		€ 11.500,00				
				frequency	value	yearly value
Health benefits employees				per year	€ 11.500,00	€ 11.500,00
	Number of service users			per year	250	
	Percentage of service users modal shift			fixed	10%	
	Health effect of cycling to work			fixed	46%	
	Monetary effect of health benefits saved			per year	€ 1.000,00	

Figure 15: Breakdown of the costs and benefits for the Employer

In terms of benefits, the decrease in employees that commute to work by car may positively benefit the employer in terms of a decreased need to develop new parking infrastructure. Assuming that on average a parking space is used 20% of the time, whereas the cost of building a new parking space on average would

[21] *https://ecoscore.be/en/info/ecoscore/co2*
[22] *https://www.en-former.com/en/metric-ton-co2-cost/*

amount €14.391[23], this would imply that €71.955 can be saved for the development of new parking infrastructure. In addition to saved parking infrastructure expenses, the employer also benefits from the health benefits generated by employees through use of the service. Commuting to work by bike may positively influence health, for which cycling to work may decrease the risk of developing cancer or vascular diseases by 46%[17], in turn decreasing the compensation employers are required to offer to employees. Assuming this compensation on average is €1000 per year, the health benefits generated through use of the service amount to €11.500 on a yearly basis. Note that an increase in user base would further increases these benefits.

5.4.4. Results of business case analysis

Based on the selected parameter settings, the business case results as presented in Figure 9 are obtained. One can see that for the current parameter settings, most of the actors in the business model design generate a positive financial outcome, although the balance for the employer is dependent on fixed benefits, which may trouble its long-term viability. Although the traffic manager is required to make initial investments with respect to ensuring that the traffic light infrastructure is able to communicate with the service (amounting an initial investment of €20.000), the financial profit generated as a result of decreased pollution (as a percentage of service users will shift their mode of transport from cars to bicycles / public transport) is considerable enough to offset this initial investments after the first year (meaning that the traffic manager / city is able to break even one year after deployment). A similar case can be observed for the service provider, which is able to offset its initial investment of €1000 (to develop the service application environment) through the service fee received from the employer. For the employer, adoption of the service is key. In the current scenario, the health benefits struggle to outweigh the decrease in parking income and service paid to do so. Although significant savings are generated with regards to a need for parking infrastructure, the variable costs in the current are significantly large that for the current user base the generated health benefits cannot outweigh this. However, if we consider the position of the service provider (which generates significant financial returns), the service fee can potentially be lowered for the employer to stimulate business model viability. For example, a decrease in service fee from €10,00 to €5,00, would enable the employer to sustain financial viability for an additional 2 years. Note again that if user adoption increases, this will further contribute to the viability of the model for the employer.

Service Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Cost of software develop	€ 1.000,00	fixed	Service fee	€ 3.000,00	per year
Cost of software mainten	€ 1.200,00	per year			
Total	€ 1.200,00		**Total**	€ 3.000,00	
Yearly balance	€ 1.800,00				
Fixed investment	€ 1.000,00				

Traffic Manager

Costs	Value	Frequency	Benefits	Value	Frequency
Cost of infrastructure d	€ 20.000,00	fixed	Decreased pollution	€ 44.352,00	per year
Cost of infrastructure m	€ 24.000,00	per year			
Total	€ 24.000,00		**Total**	€ 44.352,00	
Yearly balance	€ 20.352,00				
Fixed investment	€ 20.000,00				

Employer

Costs	Value	Frequency	Benefits	Value	Frequency
Service fee	€ 3.000,00	per year	Decreased parking expenditur	€ 71.955,00	fixed
Cost of bike scheme	€ 45.700,00	fixed	health benefits employees sav	€ 11.500,00	per year
Decrease in parking incor	€ 15.000,00	per year			
Total	€ 18.000,00		**Total**	€ 11.500,00	
Yearly balance	€ -6.500,00				
Fixed investment	€ -26.255,00				

Figure 16: Financial Dashboard BM02

[23] https://www.chapman.edu/campus-services/sustainability/_files/environmental-audit/photos-2017/Transportation-ch6-2017.pdf

6. BM03- More Efficient Fleet Operation

6.1. Description

In the business model blueprint depicted in Figure 17, the proposed service solution is catered to fleet operators (e.g., logistics & transportation companies), which finance the service directly to equip their vehicles with the C-ITS service and benefit from reduced fuel consumptions over their entire fleet which may offset the corresponding costs for deploying and operating the service.

The service provider offers the GLOSA with the aim to improve the flow of traffic and reduce pollution due to fuel use, with the expectations that the drivers, who are informed of the optimal traffic behaviour, can use this information to improve decision making with regards to their speed (see Section 19.8 for more information about the GLOSA service). The more vehicles adopt the service, the more benefits can be experienced in the traffic flow and reduction of fuel use. The drivers can use the service (offered on a software application installed either an on-board unit or smartphone application) that tracks the speed and location of the user and integrates this data with real-time traffic data to provide the best cruising advice. The road operator provides the necessary infrastructure for the GLOSA, that requires application to interact with nearby or oncoming intelligent traffic lights, collect data with regards to traffic light state information to calculate an optimal speed advice. In turn, this should benefit the road operator through a reduction in CO2-emissions and an improved traffic flow and efficiency. The data provider is responsible for collecting and transforming the raw data collected by the application into usable data elements, which is consequently transferred to the service provider. It receives a fee for transforming the data also to cover the operational costs that are incurred in doing so.

The value proposition of the model is *more efficient fleet operation (via GLOSA)*. Optimized implies that the fleet of the fleet operators can maintain a more regular speed whereas unnecessary braking or stopping can be diminished or avoided which in turn should result in reduced fuel consumptions over their entire fleet.

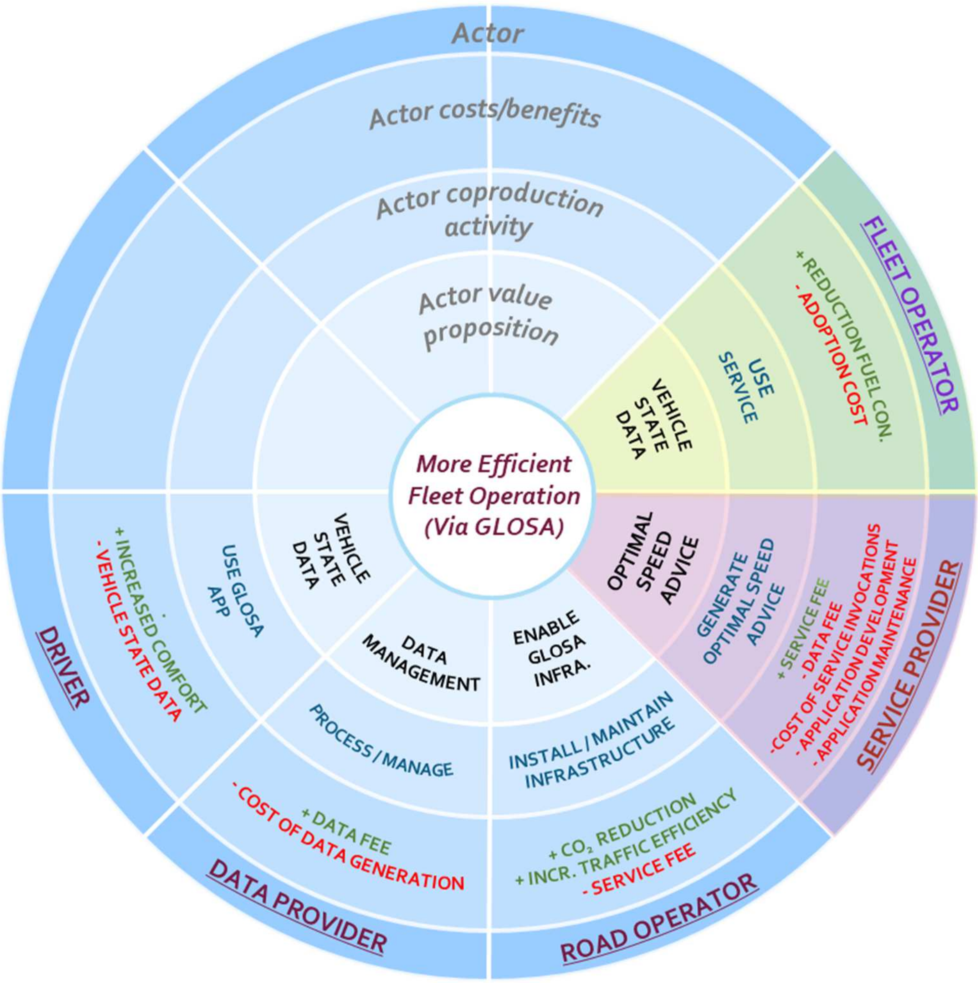

Figure 17: Business model radar for BM03- More Efficient Fleet Operation

6.2. Involved Actors

Fleet operator (customer)

The fleet owners can finance the service directly and will distribute the service over its drivers. Therefore, their value coproduction activity is fleet-wide the *usage of the service* and their value proposition is to provide *vehicle state data* through the usage of the service. Consequently, the fleet owners will benefit from reduced fuel consumptions over their entire fleet which may offset the costs of buying and distributing the service.

Service provider (orchestrator)

The service provider is responsible for generating an optimal speed advice for car drivers, based on integrated traffic and user data (received from the data provider). The service provider moreover should ensure that the software application is maintained, in order to warrant that an optimal speed advice can continuously be offered to users. Therefore, the value proposition of the service provider is the *optimal speed advice*, which is conducted through the co-production activity of *generating this advice*. The service provider will benefit from a *service fee* for offering the service, whereas the provider will also become owner of the *vehicle state data* (which may be sold on or used in different business models). The service provider will incur costs for receiving the (useable) *user data (*paying a *data fee* to the *data provider*), whereas *operational costs* will be incurred for managing the service relating to developing and maintaining the service as well as handling service invocations.

Road operator (core partner)

In order for the application to be able to interact with nearby or oncoming traffic lights, the traffic lights should be connected to or equipped with roadside units which can communicate with the service application (assuming G5 based communication). In turn, the application can collect data with regards to traffic light state information and calculate an optimal speed advice accordingly. Therefore, the value proposition offered by the road operator is the *enabling of the GLOSA infrastructure*. This is achieved through the co-production activity of *installing and maintaining the GLOSA infrastructure*. Enabling the service allows car drivers to maintain a more regular speed and drive more eco-friendly. In turn, this should benefit the road operator through a *reduction in* CO_2*-emissions* and an *improved traffic flow and efficiency*. The road operator will however incur costs for installing and maintaining the necessary GLOSA infrastructure.

Data provider (core partner)

The data provider is responsible for collecting and transforming the raw data collected by the software application into usable data elements, which consequently is transferred to the service provider. Therefore, the value proposition of the data provider is *data management*, which is offered through the co-production activity of processing and managing the raw data. The data provider receives *a fee* for transforming the data, whereas *operational costs* are incurring for doing so (e.g., *cost of data operation*).

Driver (core partner)

The driver uses the software application (either an on-board unit or smartphone application) to receive optimized speed advice. The application tracks the speed, location and direction of the user and can interact with upcoming traffic lights to collect state information. Accordingly, when a user approaches a specific traffic light, the user is either advised to maintain the current speed or accelerate to reach the next traffic light on time, or advised to slow down in order for the traffic light to turn green again, in case the current state is red. For the service to be effective, vehicle state data with regards to the car driver's location, speed and direction is required. Therefore, the value proposition of the driver is to provide vehicle state data, which is generated through the co-production activity of activating and using the GLOSA software application. In turn, the car driver benefits from a reduction of fuel consumption, as unnecessary braking and acceleration are reduced. Moreover, as a more regular speed can be maintained, the driver should experience increased comfort while driving. As a cost, the car driver must provide vehicle state data, which may influence the privacy of the car driver.

6.3. Operational scenario

The service provider offers the GLOSA with the aim to improve the flow of traffic and reduce pollution due to fuel use, with the expectations that the drivers, who are informed of the optimal traffic behaviour, can use this information to improve decision making with regards to their speed. The more vehicles adopt the service, the more benefits can be experienced in the traffic flow and reduction of fuel use.

Fleet operators finance the service directly to equip their vehicles with the C-ITS service and benefit from reduced fuel consumptions over their entire fleet which may offset the corresponding costs for deploying and operating the service.

The drivers can use the service (offered on a software application installed either an on-board unit or smartphone application) that tracks the speed and location of the user and integrates this data with real-time traffic data to provide the best cruising advice.

The road operator provides the necessary infrastructure for the GLOSA, that requires application to interact with nearby or oncoming intelligent traffic lights, collect data with regards to traffic light state information to calculate an optimal speed advice. In turn, this should benefit the road operator through a reduction in CO2-emissions and an improved traffic flow and efficiency.

The data provider is responsible for collecting and transforming the raw data collected by the application into usable data elements, which is consequently transferred to the service provider. It receives a fee for transforming the data also to cover the operational costs that are incurred in doing so.

The road operator provides the necessary infrastructure for the service, that requires application to interact with nearby or oncoming (intelligent) traffic lights, collect data with regards to traffic light state information to calculate an optimal speed advice. In turn, this should benefit the road operator through a reduction in CO2-emissions and an improved traffic flow and efficiency. The data provider is responsible for collecting and transforming the raw data collected by the application into usable data elements, which is consequently transferred to the service provider. It receives a fee for transforming the data to cover the operational costs that are incurred in doing so.

The operational scenario is depicted in the form of a choreography diagram respectively in Figure 18. The choreography diagram includes an initial set-up scenario for the C-ITS solution (the flow at the top of the figure) and the operational scenario (the flow at the bottom of the figure). (Appendix-C describes how a choreography diagram can be interpreted.)

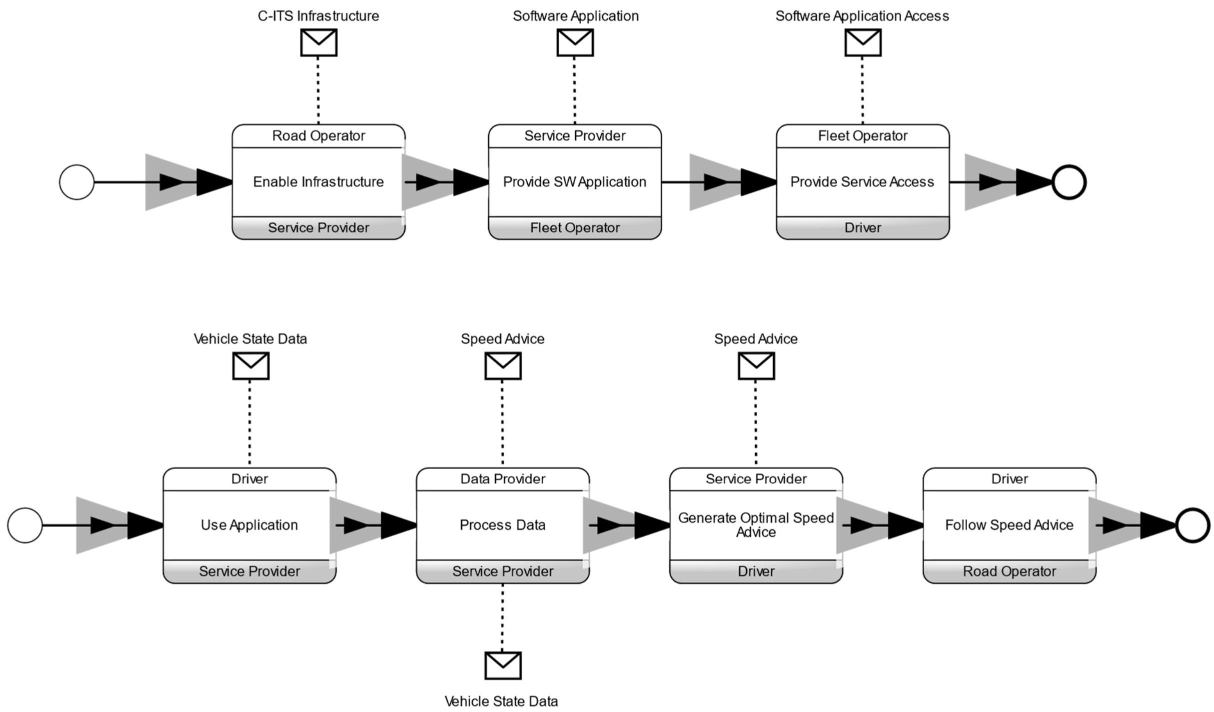

Figure 18: Choreography diagram for BM03 - More Efficient Fleet Operation

6.4. BM03 Business Case Analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM03 is depicted by means of the value capture diagram presented in Figure 19. As illustrated, BM03 consists of 5 actors, of which 4 (namely the fleet operator, service provider, road operator and data provider) generate tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the taxi driver solely generates intangible costs and benefits (e.g., largely related to perceptions and difficult to quantify or express in financial terms). Focusing solely on the financial viability of the business model design, we therefore do not consider the perspective of the truck driver, whereas we assume that the taxi driver is incentivized or stimulated by the fleet operator to use the service.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that the road operator / municipality pays a *service fee* to the service provider to provide the service, whereas the service provider pays a *data fee* to the service provider to supplement the necessary traffic light state data to do so. As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that each of the actors also generate costs and benefits which are not based on exchange and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions, traffic efficiency and fuel consumption).

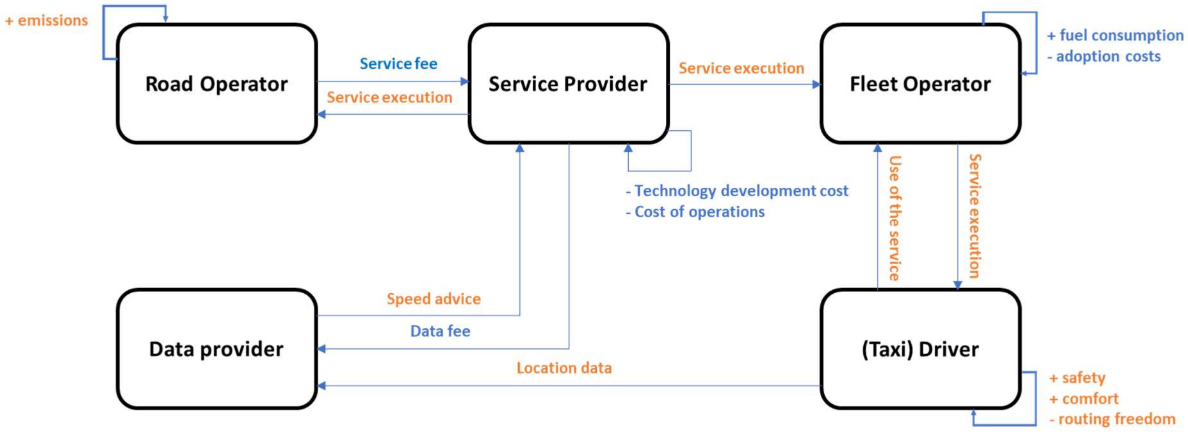

Figure 19: Value capture diagram for BM03- More Efficient Fleet Operation

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 4) have been used. These values are based on the deployments in the *Thessaloniki, Greece* deployment site where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 4: Parameter settings for BM03 business case analysis

Parameter description	Frequency	Value
Average amount of taxi drivers using the service	Fixed	1000 drivers
Average amount of trucks compliant to service policy	Fixed	100%
Average trajectory length supported by GLOSA	fixed	1 km[24]
Average frequency trajectory is passed by a user	Per day	20 times
Number of intersections supported through GLOSA	Fixed	12[24]
Average waiting time at an intersection	Fixed	1 minute
Average fuel consumption	Fixed	0,073 L/km[25]
Average decrease in fuel consumption as a result of GLOSA	Fixed	0,4%[26]
Percentage of stops on average prevented as a result of GLOSA	Fixed	20%
Fuel consumption per intersection stop (idling)	Fixed	0,07 L[27]
Emissions of a ton CO_2	Per liter	0,0264 tCO_2[28]
Value of a ton CO_2	Fixed	84,00 euro[29]
Price of fuel	Fixed	1,59 euro30
Data fee (paid by the service provider to the data provider)	Per month	1300 euro
Service fee (paid by the road operator to the service provider)	Per month	2500 euro
Cost of service invocations	Per month	500 euro
Cost of application development	Fixed	10.000 euro
Cost of application maintenance	Per month	500 euro
Cost of service adoption	Per month	100 euro
Cost of data generation	Per month	1000 euro

[24] *Information obtained through Video-Conference Thessaloniki [10-03-2021]*
[25] *https://www.osti.gov/pages/servlets/purl/1339511#:~:text=The%20average%20fuel%20consumption%20is,regulation%20(EU%2C%202009), an average consumption of 7.32 litres per 100 km*
[26] *C-MobILE D2.1. Ex-Ante Cost Benefit Analysis*
[27] *https://carfromjapan.com/article/car-maintenance/how-much-gas-does-idling-use/*
[28] *https://ecoscore.be/en/info/ecoscore/co2*
[29] *https://www.en-former.com/en/metric-ton-co2-cost/*
[30] *https://www.anwb.nl/vakantie/reisvoorbereiding/euro-95-benzineprijzen-europa - Greece [29-04-2021]*

6.4.1. Service Provider

The detailed tab for the service provider is illustrated in Figure 20 (representing the costs on the left and the benefits on the right). One can see that both the costs and benefits are rather straightforward. The service provider pays a data fee (amounting €1.300) per month to the data provider to compensate the data provider for transforming the raw data into input for the service. In addition to this data fee, the service provider incurs costs related to service invocations made by the end-user (amounting a monthly expense of €500), as well as costs related to the development and maintenance of the software application (€10.000 fixed and €500 monthly respectively). To compensate for the costs incurred, the service provider receives a monthly service fee from the road operator, in this scenario set to €2.500 per month.

	variable	fixed			
Data fee	€ 15.600,00				
			frequency	value	yearly value
Data fee			per month	€ 1.300,00	€ 15.600,00
	variable	fixed			
Cost of service invocation	€ 6.000,00				
			frequency	value	yearly value
Cost of service invocations to end-user			per month	€ 500,00	€ 6.000,00
	variable	fixed			
Application development		€ 10.000,00			
			frequency	value	yearly value
Cost of service invocations to end-user			fixed	€ 10.000,00	€ 10.000,00
	variable	fixed			
Application maintenance	€ 6.000,00				
			frequency	value	yearly value
Cost of service invocations to end-user			per month	€ 500,00	€ 6.000,00

	Variable	fixed			
Service fee	€ 30.000,00				
			frequency	value	yearly value
Service fee received from road operator			per month	€ 2.500,00	€ 30.000,00

Figure 20: Breakdown of the costs and benefits for the service provider

6.4.2. Fleet Operator

The detailed tab for the fleet operator is illustrated in Figure 21. As for the costs of the fleet operator, only adopting costs are considered (related to stimulating taxi drivers to use the service and ensuring that the service is used properly). For this scenario, these costs are set to €100 per month.

	Variable	fixed			
Adoption costs	€ 1.200,00				
			frequency	value	yearly value
Adoption costs			per month	€ 100,00	€ 1.200,00

		Variable	fixed			
Value of decrease in fuel consumption expenditure		€ 101.367,80				
				frequency	value	yearly value
Value of decrease in fuel consumption				per day	€ 277,72	€ 101.367,80
	Number of taxi drivers			fixed	1000	
	Average trajectory length for service (km)			fixed	1	
		Average consumption per trajectory (L)		fixed	0,083333333	
	Decrease fuel consumption driving as a result of GLOSA			fixed	0,4%	
	Percentage of stops avoided using GLOSA			fixed	20%	
	Fuel consumption per stop (L)			fixed	0,07	
	Number of intersections equipped			fixed	12	
	Price of fuel			fixed	€ 1,59	
	Frequency trajectory passed per user			per day	20	

Figure 21: Breakdown of the costs and benefits for the fleet operator

The benefits for the fleet operator with regards to service use predominantly pertain to the decrease in fuel consumption for its taxi drivers. In this business scenario, 1000 taxi drivers are considered, for which the service (e.g., GLOSA) covers a trajectory of 1 kilometer in Thessaloniki. Here GLOSA, may help in smoothening the speed travelled as well reduce the amounts of stops at intersections, in turn aiding fuel consumption. Considering an average decrease in fuel consumption as a result of GLOSA of 0.4%[31], whereas the use of GLOSA may also enable taxi drivers to stop 20% less at intersections (assuming a consumption of 0,07 liters per stop as well as 12 intersections for Thessaloniki), the savings per day amount to €262,00 per day (under an average fuel consumption of 1/12 L/km, a fuel price of €1,59/L[24] and a frequency of passing the service enabled trajectory of 20 times per day). On a yearly basis, this would amount to savings for the fleet operator of €101.367,80.

6.4.3. Data Provider

The detailed tab for the data provider is illustrated in Figure 22. As can be observed, the costs and benefits for the data provider are straightforward. With regards to generating and transforming the data, the data provider incurs €1.000 per month. These costs are compensated by a fee paid by the service provider (as expressed earlier, in this scenario set to €1.300).

[31] *D2.1 Ex-Ante Cost Benefit Analysis. C-MobILE.*

	variable	fixed			
Cost of data generation	€ 12.000,00				
			frequency	value	yearly value
Cost of data generation			per month	€ 1.000,00	€ 12.000,00

	variable	fixed			
Data fee	€ 15.600,00				
			frequency	value	yearly value
Data fee			per month	€ 1.300,00	€ 15.600,00

Figure 22: Breakdown of the costs and benefits for the data provider

6.4.4. Road Operator

The detailed tab for the road operator is illustrated in Figure 23. The costs for the road operator pertain to the service fee paid to the service provider to operate the service, enabling the road operator in return to also generate benefits as result of decreased pollution. Analogously to the calculations for the fleet operator, use of the service by taxi drivers decreases fuel consumption because of smoothened travel speed and decreased number of stops. For the road operator, this decrease in fuel consumption can be translated into a decrease of CO_2 emissions. In this scenario, it is assumed that the consumption of 1 liter of fuel generates 0,00264 tCO_2[2]. Considering the same parameter settings as for the fleet operator, and assuming that a decrease of a ton CO_2 emissions has a value of €84,00, per day the benefits for the road operator would amount to €387,34, or €141.379,39 per year. As can be observed, these benefits significantly outweigh the costs related to the service fee paid.

	Variable	fixed			
Service fee	€ 30.000,00				
			frequency	value	yearly value
Service fee received from road operator			per month	€ 2.500,00	€ 30.000,00

		Variable	fixed			
Value of decreased pollution		€ 141.379,39				
				frequency	value	yearly value
Value of decrease in fuel consumption				per day	€ 387,34	€ 141.379,39
	Number of taxi drivers			per month	10000	
	Average trajectory length for service (km)			fixed	1	
	Average consumption per trajec			fixed	0,083333333	
	Decrease fuel consumption driving as a result of (			fixed	0,4%	
	Percentage of stops avoided using GLOSA			fixed	20%	
	Fuel consumption per stop (L)			fixed	0,07	
	Number of intersections equipped			fixed	12	
	Emssions of tCO2 per litre			fixed	0,00264	
	Value of tCO2			fixed	€ 84,00	
	Frequency trajectory passed per user			per day	20	

Figure 23: Breakdown of the costs and benefits for the road operator

6.4.5. Results of Business Case Analysis

Based on the selected parameter settings, the business case results as presented in Figure 24 are obtained. One can see in that for the chosen parameter settings, all actors for BM03 obtain a positive financial outcome. Both the fleet operator and road operator (municipality) benefit significantly from the decrease in fuel consumption through use of GLOSA, either in the form of savings on fuel expenditures or in terms of decreased emissions respectively. Considering that the application is currently offered free of charge for the fleet operator, one may consider here to explore different revenue models that would further support the financial viability of the business model design (possibly charging the fleet operator after initial adoption and sustained use of the service). In addition, the traffic efficiency benefits for the road operator (due to the increased traffic speed), even though a relatively short trajectory is considered that is supported through GLOSA, are considerable and significantly outweigh the service fee paid to the service provider. Both the data provider and service provider can compensate the costs incurred with respect to data generation and service operation, although it should be noted that the service provider is required to make a fixed investment of €10.000 to support the development of the application. Given the yearly profit of the service provider currently stipulated, this implies that the service provider will only break even after roughly 4 years. Considering the large benefits generated by the road operator, here one may consider increasing the service fee (from €2500 to €3000), which would already facilitate the service provider to break even after 1.5 years.

Service Provider

Costs	Value	Frequency	Benefits	Value	Frequency
data fee	€ 15.600,00	per year	Service fee	€ 30.000,00	per year
cost of service invocation	€ 6.000,00	per year			
application development	€ 10.000,00	fixed			
application maintenance	€ 6.000,00	per year			
Total	€ 27.600,00		**Total**	€ 30.000,00	
Yearly balance	€ 2.400,00				
Fixed investment	€ 10.000,00				

Fleet operator

Costs	Value	Frequency	Benefits	Value	Frequency
Adoption costs	€ 1.200,00	per year	Reduction of fuel consumption	€ 101.367,80	per year
Total	€ 1.200,00		**Total**	€ 101.367,80	
Yearly balance	€ 100.167,80				
Fixed investment	€ -				

Data Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Operational costs	€ 12.000,00	per year	Data fee	€ 15.600,00	per year
Total	€ 12.000,00		**Total**	€ 15.600,00	
Yearly balance	€ 3.600,00				
Fixed investment	€ -				

Road operator

Costs	Value	Frequency	Benefits	Value	Frequency
Service fee	€ 30.000,00	per year	Value of decreased emissions	€ 141.379,39	per year
Total	€ 30.000,00		**Total**	€ 141.379,39	
Yearly balance	€ 111.379,39				
Fixed investment	€ -				

Figure 24: Financial Dashboard BM03

7. BM04- Hassle-free Event Experience

7.1. Description

Many large cities are characterized by heavy traffic during daily rush hours, which becomes worse when large events, such as football matches or concerts, are held in premises located in or close to city centres. One of the measures to counter this problem is to endorse the use of public transportation. However, addressing this challenge involves a choreography between a large variety of stakeholders, both public, the private and the individual kind.

In this business model, the targeted value-in-use for the event visitors is a hassle-free concert experience. Hassle-free implies that by taking public transport to an event instead of travelling by car, the event visitor benefits from not having to worry about waiting in traffic, dealing with congestion, or parking the car at the location, whereas the visitor can experience more freedom at the event location. To facilitate that, the service provider assesses the current and near-future traffic conditions at large events. Based on these conditions, the service provider offers free (or with increasing discounts based on the traffic data) public transport tickets with the aim to stimulate visitors to use a different mode of transport and reduce traffic at and around the event location. This is accommodated by a travel advice with regards to connections between modes of transport, trip duration and expected departure and arrival times. Mode & trip time advice (e.g., by incentives) aims to provide a traveller with an itinerary for a multimodal passenger transport journey, considering real-time and/or static multimodal journey information.

The blueprint business model is given in Figure 25.

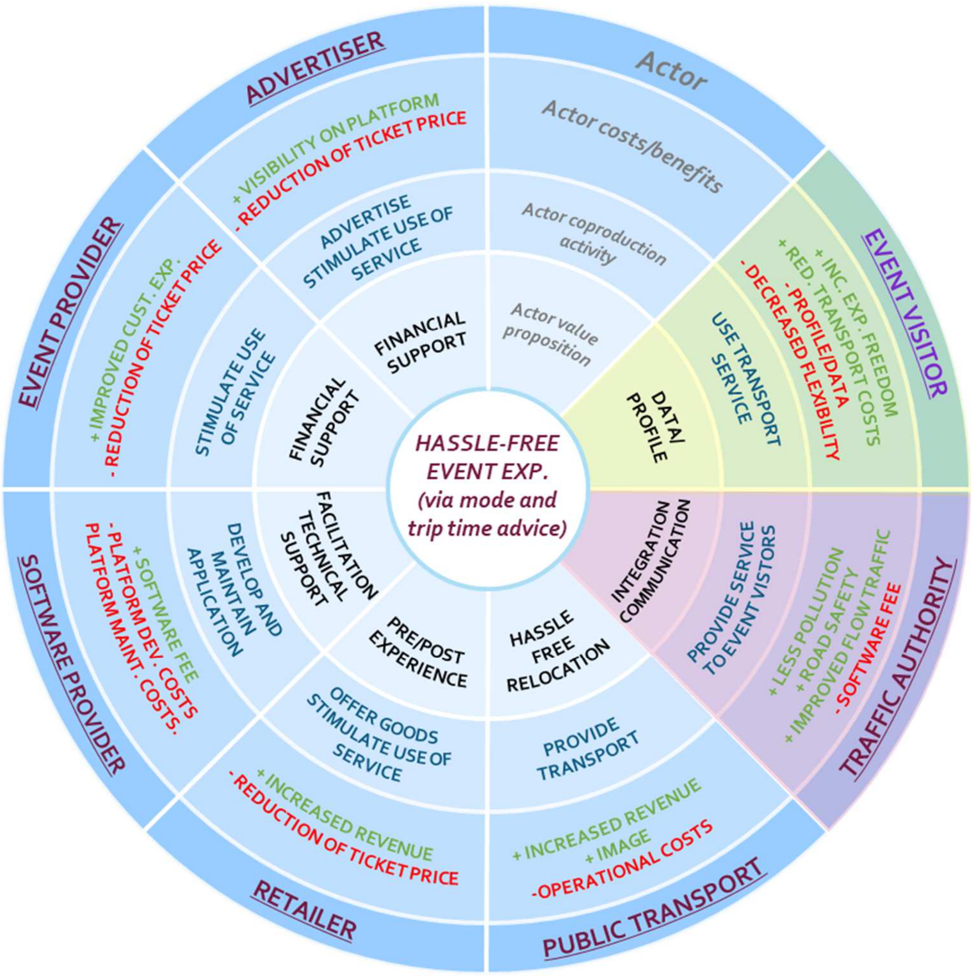

Figure 25: Business model radar for BM04- Hassle-free Event Experience

7.2. Involved Actors

Event visitor (customer)

The event visitor can create an account on the platform of the service provider to access its services, which includes advice on itinerary for travelling to the event location and may include discounts for public transport tickets (or even for free) depending on the current traffic conditions at the event location. The advice can be customized based on the preferences of the user as well as the specific offerings. The value proposition of the event visitor therefore is *profile data*, which can be used to customize the service offerings, but can also be used for financing the service. Profile data is generated through the co-production activity of *using the (transport) service,* as to access the service visitors must create an account and indicate their preferences. As taking the car is avoided, the event visitor will benefit from *increased freedom* (or *decreased hassle of managing the car*, e.g., the event visitor can enjoy a drink*)*. Moreover, since tickets will be offered at reduced rates, the event visitor will benefit from *less transport costs*. As a cost, the event visitor should present profile data, which may influence his or her privacy. Furthermore, as the event visitor is bound to public transport arrival and departure times, the event visitor has *less travel flexibility*.

Traffic authority (orchestrator)

The traffic authority (or a service provider in case the service is offered through private-public partnerships) is responsible for offering the platform which event visitors can use to receive information with regards to the optimal mode of transport to take as well as how to arrive at the event location, but also to buy and acquire tickets through. Moreover, acquiring the transport tickets (at reduced prices) as well as travel and arrival times should be synchronized with the public transport operator. Therefore, the value proposition of the service provider is to provide *integration and communication*. This is conducted through the co-production activity of providing the service solution to customers, for which the traffic authority collects and integrates data from the various involved stakeholders. The traffic authority will pay *a software fee* to the software provider for use of the software platform (such that the service can be provided). Through operation and use of the service, the traffic authority can benefit from decreased pollution, increased road safety and improved flow of traffic.

Public transport operator (core partner)

The public transport operator is responsible for transporting the event visitors to the event location. The value proposition of the public transport operator therefore is *hassle free relocation*, emphasizing that the event visitor will obtain a comfortable and efficient travelling experience (in contrast to travelling by car). This will be conducted through the co-production activity of providing public transport. As taking public transport is stimulated, the public transport operator will benefit from *increased revenues*, whereas in addition the public transport operator may benefit from increased *image* (taking public transport as a suitable travelling alternative to travel by car). The public transport operator will however incur increased operational costs because of the increased customer base (as well as handling new customers).

Retailer (core partner)

Through offering reduced rates for early public transport tickets, event visitors may be stimulated to arrive early at the event location. Profile data of event visitors can be used by retailers to customize their offerings to become more appealing. Therefore, the value proposition of retailers is to take care of the pre and post experience of event visitors. The pre and post experience will be created through offering customized goods and services based on the profile data of visitors. Retailers will benefit from increased (attention of) customers, whom moreover can spend more as public transport tickets are offered at reduced rates. Part of these increased revenues can be invested in ensuring that the business model is financially feasible (e.g., covering for discounts on public transport tickets).

Software provider (core partner)

The software provider is responsible for developing and maintenance the software platform used by the traffic authority to operate the service. Accordingly, the value proposition of the software provider is the *facilitation* of the service, and to provide *technical support* where needed. The software provider does so via the co-production activity of *developing and maintaining the software platform / application*. With respect to the software platform, the software provider incurs costs related to its development and maintenance. In return, the software provider receives a *software fee* from the traffic authority to compensate these costs.

Event provider (enriching partner)

The event provider is responsible for hosting the event, to which the service solution is catered. As the service solution may enhance the full customer experience for the event, the event provider may be stimulated to further support offering the service (through incurring costs of providing a *financial contribution* towards offering the service). As a result, the event provider will benefit from *increased image*, as event visitors will enjoy a hassle-free experience, as well as *increased customer expectations* (as event visitors will go home more satisfied). This may further stimulate customers to buy tickets for future events. As a sponsoring party, the value proposition of the event provider is the *event experience*, which is offered through the co-production activity of *hosting the event*.

Advertiser (enriching partner)

Advertisers may be stimulated to further enhance the financial feasibility of the business model scenario, as in-app adds can be included for the service application, generating visibility for the advertisers, if advertisers contribute towards reducing the tariffs of ticket prices (in order to stimulate the use of the service). Accordingly, the value proposition of the advertiser is to provide *financial support*, which is generated through the co-production activity of *advertising* and *stimulating the use of the service*. Consequently, as a cost, the advertiser compensates part of the ticket price for event visitors, but in return can benefit from increased visibility of advertisements in the software application (used by event-visitors).

7.3. Operational scenario

In the business service scenario, *event visitors* are stimulated to take public transport to visit a large event instead of travelling by car based on the density and flow of traffic near the event location. To do so, the *service provider* assesses the current traffic conditions at large events. Based on these conditions, the *service provider* may offer to *event visitors* free (or with increasing discounts based on traffic data) public transport tickets to stimulate *event visitors* to use a different mode of transport and reduce traffic at the event location. This will be accommodated by a travel advice with regards to connections between modes of transport, trip duration and expected departure and arrival times. As such, the *event visitor* will benefit from reduced travelling expenses and increased travelling comfort, as the *event visitor* does not have to endure traffic congestion at the event location, whereas *event visitors* can benefit from increased freedom from not having to manage the car.

The service provider incurs platform costs for offering the service, for which a fee will be obtained as compensation. As public transportation is motivated, the transport operator benefits from increased revenues due to increased travellers, which in turn may benefit the image of taking public transport as a suitable travelling alternative. Through offering reduced rates for early public transport tickets, event visitors can be stimulated to arrive early at the event location. Profile data of event visitors can be used by retailers to customize their offerings to become more appealing. They can offer pre and post experience through customized goods and services based on the profile of the visitors. Retailers benefits from increased (attention of) customers, whom moreover can spend more as public transport tickets are offered at reduced rates. Part of these increased revenues can be invested in ensuring that the business model is financially feasible (e.g., covering for discounts on public transport tickets).

The city or municipality can be included as an enriching partner to further finance the service solution. As the municipality will benefit from decreased pollution, an improved flow of traffic and as such an improved image, the municipality might be willing to subsidize offering the service solution. The event provider is responsible for hosting the event, for which the service solution is catered. As the service solution may enhance the full customer experience for the event, the event provider can be stimulated to further support offering the service (through incurring costs of providing a financial contribution towards offering the service). As a result, the event provider benefits from increased image, as event visitors would enjoy a hassle-free experience, as well as increased customer satisfaction.

The operational scenario is depicted in the form of a choreography diagram respectively in Figure 26. The choreography diagram includes an initial set-up scenario for the C-ITS solution (the flow at the top of the figure) and the operational scenario (the flow at the bottom of the figure). (Appendix-C describes how a choreography diagram can be interpreted.)

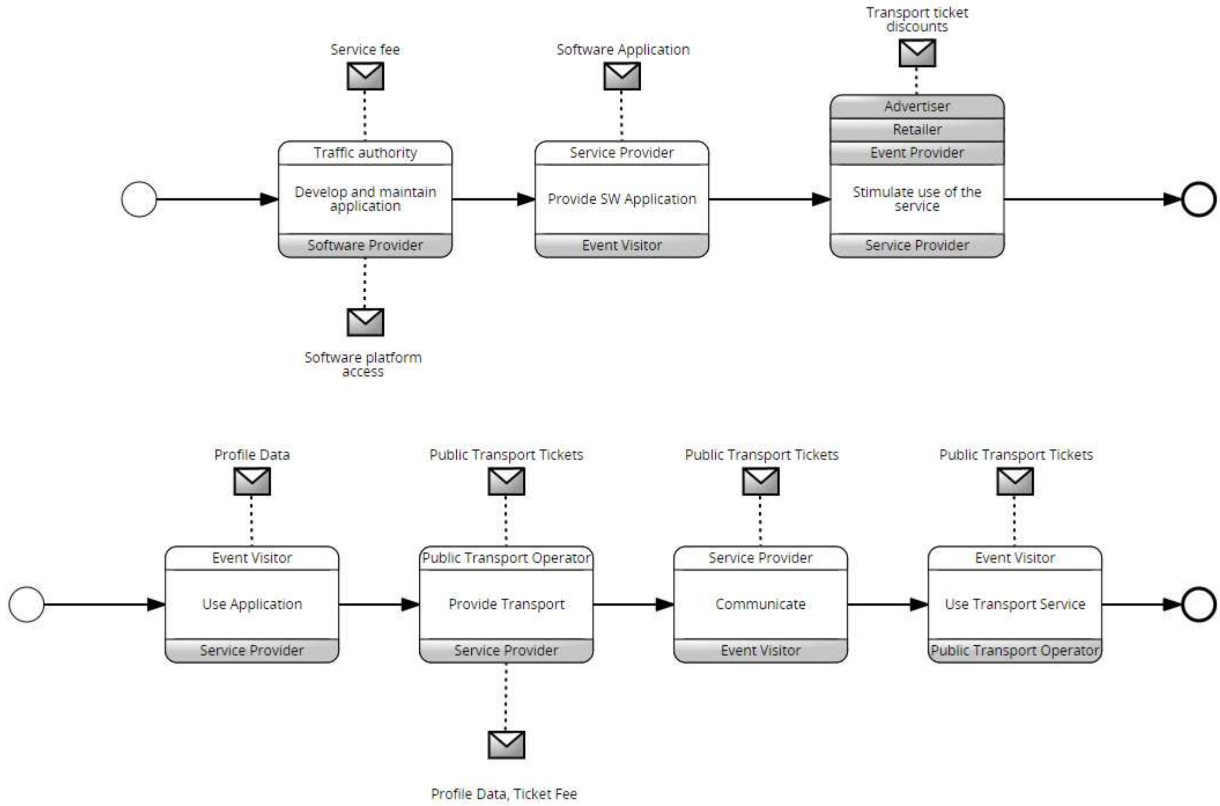

Figure 26: Choreography diagram for BM05- Hassle-free Event Experience

7.4. BM04 Business case analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM04 is depicted by means of the value capture diagram presented in Figure 27. As illustrated, BM04 consists of 7 actors, of which 6 (namely the traffic authority, public transport operator, retailer, software provider, event provider and advertiser) generate financial or tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the event visitor (although receiving a discount through use of the service and avoiding transport costs) generates largely intangible costs and benefits (e.g., largely related to perceptions and difficult to quantify or express in financial terms). Accordingly, we omit the perspective of the event visitor for the financial analysis of the business case for the business model design and focus on the remaining 6 parties. In addition, costs and benefits such as image, improved customer experience and visibility (which have largely indirect financial effects) are also not taken into account for the business case analysis, as quantifying these items would require ample assumptions with regards to their financial effects, reducing their overall accuracy. Note however that these costs and benefits should not be neglected (particularly for the event provider and advertiser), but rather should be compared or contrasted against the financial costs incurred.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that, as mentioned, the traffic authority pays a *software fee* to the software, whereas the *reduction of ticket prices* can be altered for the event provider, advertiser and retailer to stimulate further use of the service. As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that each of the actors also generate costs and benefits which are not based on exchange and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions, traffic efficiency and fuel consumption).

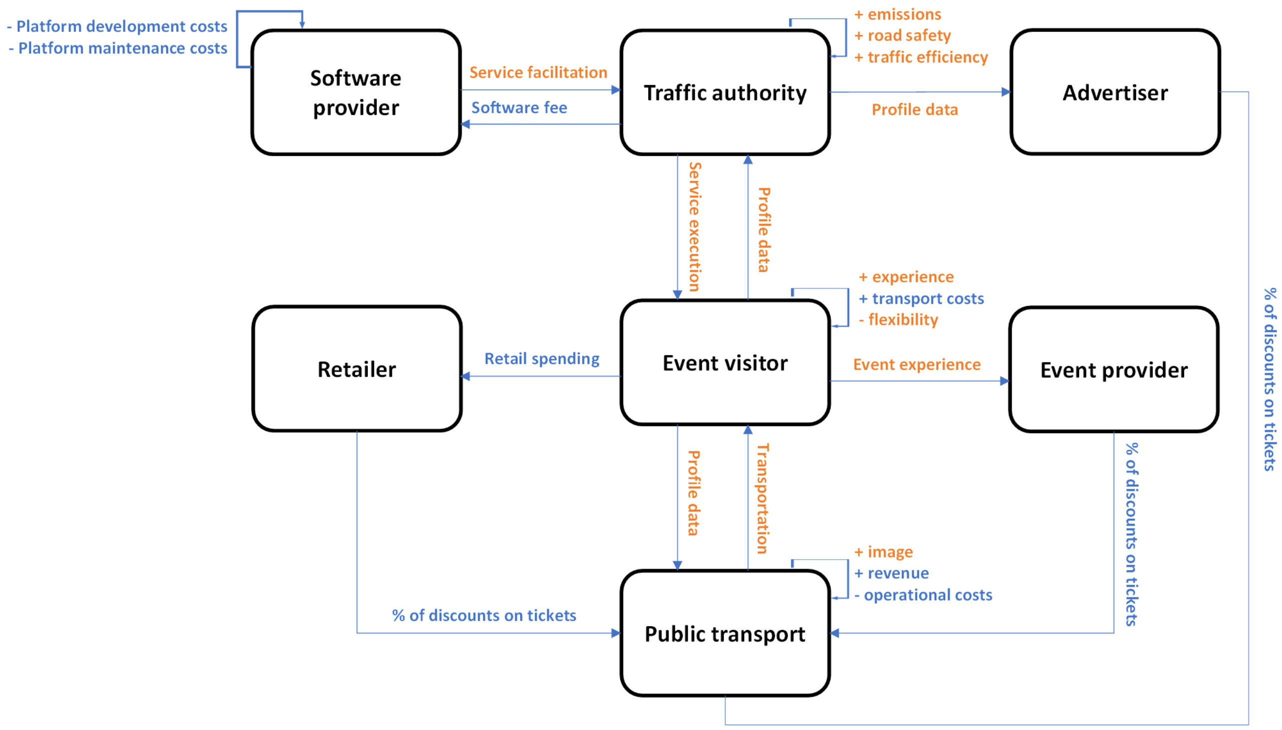

Figure 27: Value capture diagram for BM04 – Hassle Free Event Experience

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 5) have been used. These values are based on the deployments in *Copenhagen, Denmark deployment site* where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 5: Parameter settings used for BM04 business case analysis

Parameter description	Frequency	Value
Average amount of event visitors using the service	Per month	80 users
Number of events	Per month	12 events
Average price of a public transport ticket	Fixed	5,00 euro36
Percentage of users that shift from *car* to *public transport*	Fixed	20%
Average trip distance for an event visitor	Fixed	40 km
Average fuel consumption	Fixed	0,073 L/km32
Fuel consumption per intersection stop (idling)	Fixed	0,07 L33
Emissions of a ton CO_2	Per liter	0,0264 tCO234
Value of a ton CO_2	Fixed	84,00 euro35
Percentage average speed increase as a result of service	Fixed	0,1%
Average speed in Copenhagen	Fixed	50 km/h36

[32] https://www.osti.gov/pages/servlets/purl/1339511#:~:text=The%20average%20fuel%20consumption%20is,regulation%20(EU%2C%202009), an average consumption of 7.32 litres per 100 km
[33] https://carfromjapan.com/article/car-maintenance/how-much-gas-does-idling-use/
[34] https://ecoscore.be/en/info/ecoscore/co2
[35] https://www.en-former.com/en/metric-ton-co2-cost/
[36] Information obtained through Video-Conference Copenhagen [15-03-2021]

Parameter description	Frequency	Value
Value of time savings	Per minute	0,24 euro37
Number of road users in inner city of Copenhagen	Per month	200.000
Average trip distance in Copenhagen	Fixed	15 km
Percentage decrease in road accidents	Fixed	0,48%38
Number of fatalities in road accidents	Per year	170 fatalities39
Cost per fatality as a result of road accidents	Fixed	2.800.000 euro40
Percentage compensation offered for tickets (retailer)	Fixed	50%
Percentage compensation offered for tickets (event provider)	Fixed	25%
Percentage compensation offered for tickets (advertiser)	Fixed	25%
Percentage increase in operational costs	Per user	1%
Average operational costs	Per user	2,50 euro
Average retail spending	Per event	25,00 euro
Application development cost	Fixed	5.000 euro
Application maintenance cost	Per month	1.000 euro
Software fee	Per month	2.000 euro

7.4.1. Software provider

The detailed tab for the software provider is illustrated in Figure 28. One can see that the costs for the software provider pertain to the development and maintenance of the software platform and application required to facilitate the service. In this scenario, these costs are set to €5.000 fixed and €1.000 per month respectively. In return for these expenses, the software provider receives a software fee from the traffic authority (amounting €2.000 per month), such that the traffic authority (as the orchestrator of the business model design and service) is able to provide the service to the end-users.

	variable	fixed	frequency	value	yearly value
Platform costs	€ 12.000,00	€ 5.000,00			
Application development cost			fixed	€ 5.000,00	€ 5.000,00
Application maintenance cost			per month	€ 1.000,00	€ 12.000,00

	Variable	fixed	frequency	value	yearly value
Software fee	€ 24.000,00				
Software fee			per month	€ 2.000,00	€ 24.000,00

Figure 28: Breakdown of the costs and benefits for the software provider

7.4.2. Public transport operator

The detailed tab for the software provider is illustrated in Figure 28. The costs for the public transport operator pertain to increased operational expenses, as due to the service an influx of users for public transport can be expected. Assuming that per event, 80 users of the service can be expected, whereas per month on average 12 events are hosted, and further assuming that the operational costs per user are expected to increase by 1% and on average the operational costs per user per month amount €2,50, this would yield a cost per month of €24,00 for the expected amount of users, or a yearly expense of €288,00. These costs are offset by the increase in revenue that is generated through stimulated use of public transport. Again, under the set parameter values for the number of events and users, and further assuming that on average the ticket price is €5,00, the public transport operator would generate monthly benefits amounting €4.800 per month (€57.600 per year), which is more than enough to outweigh the increased operational costs.

	Variable	fixed	frequency	value	yearly value
Operational costs	€ 288,00				
Increase in operational costs			per month	€ 24,00	€ 288,00
Number of users			per event	80	
Number of events			per month	12	
Percentage increase costs per user			fixed	1%	
Average operational cost per user			per month	€ 2,50	

		Variable	fixed	frequency	value	yearly value
Increased revenue		€ 57.600,00				
Compensation of tickets purchased				per month	€ 4.800,00	€ 57.600,00
	Increase in number of users			per event	80	
	Number of events			per month	12	
	Average ticket price			fixed	€ 5,00	

Figure 29: Breakdown of the costs and benefits for the public transport operator

[37] *https://checkinprice.com/average-minimum-salary-copenhagen-denmark/ Average salary of 2126,52 euro for a 37 hour work week, e.g., 0,24 ct. per minute*
[38] *D2.1 Ex-Ante Cost Benefit Analysis, effect of mode trip time advice on safety, extrapolated from the number of current users versus the number of potential users available*
[39] *D2.1 Ex-Ante Cost Benefit Analysis*
[40] *https://www.swov.nl/en/facts-figures/factsheet/road-crash-costs*

7.4.3. Retailer

The detailed tab for the retailer is illustrated in Figure 30. As explained for the business model design, the retailer may be motivated to contribute financially to the business model design as through use of the service event visitors are likely to arrive early in the city, likely resulting in increased retail spending. This financial contribution can be considered as a percentage of compensation of the ticket fee for end-users to stimulate the use of public transport. Considering for this scenario that the retailer compensates 50% of the average ticket price, and building upon the previous values for the number of users and events, the retailer incurs €28.800 yearly costs. Such costs logically should be offset by the benefits (in terms of retail spending) gained. Assuming that on average a user per event spends €25,00 on retail spending, but that since the user does not have to pay for public transport, this spending is expected to increase by 25%, the retailer is expected to generate €72.000 in increased revenue per year.

		Variable	fixed			
Reduction of ticket price		€ 28.800,00				
				frequency	value	yearly value
Reduction of ticket price				per month	€ 2.400,00	€ 28.800,00
	Number of users			per event	80	
	Number of events			per month	12	
	Average ticket price			fixed	€ 5,00	
	Percentage of compensation covered			fixed	50%	

		Variable	fixed			
Retail spending		€ 72.000,00				
				frequency	value	yearly value
Increase in retail spending due to service				per month	€ 6.000,00	€ 72.000,00
	Number of users			per event	80	
	Number of events			per month	12	
	Percentage increase in retail spending			fixed	25%	
	Average retail spending per user			fixed	€ 25,00	

Figure 30: Breakdown of the costs and benefits for the retailer

7.4.4. Traffic Authority

The detailed tab for the traffic authority is illustrated in Figure 31. The costs for the traffic authority pertain to the software fee paid to the software provider (previously set to €2000), such that the traffic authority can offer the service. Through use of the service by event visitors, the traffic authority is able to benefit from decreased pollution, increased traffic efficiency and decreased road incidents. With regards to pollution, assuming that 50% of the users shift their mode of transport from car towards public transport would result in 480 users per month that avoid generating CO_2 emissions. If we consider the average distance travelled for an event to be 40 kilometers, and if we assume a fuel consumption of 0,073 L/km[32], tCO_2 emissions per liter to amount 0,0264[34] and the value of a ton CO_2 to be €84,00[35], the decrease in pollution would be valued at €3.729,83 per year.

With regards to traffic efficiency, we consider the average speed increase because of modal trip time advice[41]. Considering an effect of 0,1[15]% as a result of mode and trip time advice on driving speed and considering an average speed of 50 km/h in Copenhagen and an average trip distance of 15 kilometers, then for the 200.000 road users present in Copenhagen on a monthly basis 3600 minutes can be saved. If we consider an average salary to be €2126,52 (e.g., €0,24 per minute for a 37-hour workweek)[37], the traffic efficiency savings would amount to €10.368 per year.

Lastly, with regards to road incidents, we consider the fraction of road users that shift their mode of transport as opposed to the number of road users in Copenhagen, and accordingly extrapolate how through use of mode and trip time advice road safety is improved. If in general of 0,48% decrease in fatal accidents can be realized through mode and trip time advice, and that on average per year 170 fatalities occur, for which each fatality would entail a cost of €2.800.000[42], use of the service under the current conditions would 'save' the traffic authority €22.848 because of a reduction in fatalities. One can see that the benefits amassed are large enough to outweigh the expenses made for the software fee paid to the software provider.

[41] *D2.1 Ex-Ante Cost Benefit Analysis. C-MobILE.*

[42] *https://www.swov.nl/en/facts-figures/factsheet/road-crash-costs*

		Variable	fixed		
Software fee		€ 24.000,00			
			frequency	value	yearly value
Software fee			per month	€ 2.000,00	€ 24.000,00

		Variable	fixed		
Value of decrease in pollution		€ 3.729,83			
			frequency	value	yearly value
Value of decrease in fuel consumption			per month	€ 310,82	€ 3.729,83
	Number of users		per event	80	
	Number of events		per month	12	
	Percentage of users that shift from car to PT		fixed	50%	
	Average distance of trip		fixed	40	
	Average fuel consumption (L/km)		fixed	0,07	
	tCO2 emissions per litre of fuel		fixed	0,00264	
	Value of tCO2 emissions		fixed	€ 84,00	

Value of improved traffic efficiency		€ 10.368,00			
			frequency	value	yearly value
Value of improved traffic efficiency			per month	€ 864,00	€ 10.368,00
	Percentage average speed increase (km/h)		fixed	0,1%	
	Average speed in Copenhagen		fixed	50	
	Road users in inner city of Copenhagen		per month	200000	
	Average trip distance in Copenhagen (km)		fixed	15	
	Value of minutes saved per road user		fixed	€ 0,24	

		Variable	fixed		
Decrease in number of road incidents		€ 22.848,00			
			frequency	value	yearly value
Monetary value decrease in road incidents			per year	€ 22.848,00	€ 22.848,00
	Number of users		per event	80	
	Number of events		per month	12	
	Road users in inner city of Copenhagen		per month	200000	
	Effect of traffic absence on road safety		fixed	1%	
	Percentage decrease in road accidents		fixed	0,48%	
	Number of fatalities in road accidents		per year	170	
	Cost per fatality of road accidents		fixed	2800000	

Figure 31: Breakdown of the costs and benefits for the public transport operator

7.4.5. Event Provider and Advertiser

The event provider and advertiser serve as an enriching role for the business model design, aimed at further stimulating the financial viability of the business model. Both parties can do so through covering part of the ticket fee price for users of the service (stimulating its use, rendering public transport essentially free for event visitors if they use the service). In this case, the event provider and advertiser are jointly responsible to cover the remaining 50% of the ticket price per user (for which the initial 50% was covered by the retailer). As indicated for the business model design, the event provider and advertiser generate intangible benefits (e.g., customer experience and visibility). Both parties should therefore consider whether these intangible benefits are strategically relevant and desired to justify compensations offered to users of the service. If in this example 25% compensation is considered per actor, both actors should consider whether the €14.400 expenses per year to do so can be offset by the expected intangible benefits.

7.4.6. Results of Business Case Analysis

Based on the selected parameter settings, the business case results as presented in Figure 32 are obtained. One can see that for the current parameter settings, all actors barring the event provider and advertiser generate a positive financial outcome. For the event provider and advertiser, this is logical, as considering the business model design their benefits have indirect financial implications (and thus for this analysis are not considered). Accordingly, event providers and advertisers should judge whether the current costs incurred / investments made can be offset by these benefits (either as these benefits are considered strategically valuable to obtain or can later be translated into financial benefits). For example, it could be worthwhile for an event provider to stimulate the service as it increased the customer experience of event visitors. This in turn may result in increased future sales of tickets for events (as customers are satisfied). Note that the current costs for the event providers and advertisers also depend on the percentage of compensation that is offered for reducing the ticket price, which can be negotiated upon. For example, in the current scenario, the retailer is expected to benefit significantly through increased retail spending. Here, retailers may be motivated to cover more of the compensation offered with respect to the public transport tickets. Considering the remaining parties, the public transport operator and traffic authority benefit significantly through deployment of the service. As users are incentivized to take public transport rather than cars (or bikes), the number of users for the public transport operator will increase, in turn increasing its revenue. The modal shift moreover is beneficial for the traffic authority, generating significant financial returns related to increased traffic efficiency and pollution, and in case accidents can realistically be avoided because of the service, in terms of road safety.

Software Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Platform costs	€ 12.000,00	per year	Software fee	€ 24.000,00	per year
Platform development	€ 5.000,00	fixed			
Total	€ 12.000,00		Total	€ 24.000,00	
Yearly balance	€ 12.000,00				
Fixed investment	€ 5.000,00				

Public Transport

Costs	Value	Frequency	Benefits	Value	Frequency
Operational costs	€ 288,00	per year	Increase revenue	€ 57.600,00	per year
Total	€ 288,00		Total	€ 57.600,00	
Yearly balance	€ 57.312,00				
Fixed investment	€ -				

Retailer

Costs	Value	Frequency	Benefits	Value	Frequency
Reduction of ticket price	€ 28.800,00	per year	Increased retail spending	€ 72.000,00	per year
Total	€ 28.800,00		Total	€ 72.000,00	
Yearly balance	€ 43.200,00				
Fixed investment	€ -				

Traffic Authority

Costs	Value	Frequency	Benefits	Value	Frequency
Operating fee	€ 24.000,00	per year	Value of decreased pollution	€ 3.729,83	per year
			Increased traffic efficiency	€ 10.368,00	per year
			Increased road safety	€ 22.848,00	per year
Total	€ 24.000,00		Total	€ 36.945,83	
Yearly balance	€ 12.945,83				
Fixed investment	€ -				

Event provider

Costs	Value	Frequency	Benefits	Value	Frequency
Reduction of ticket price	€ 14.400,00	per year	Improved experience	Not quantified	
Total	€ 14.400,00		Total	€ -	
Yearly balance	€ -14.400,00				
Fixed investment	€ -				

Advertiser

Costs	Value	Frequency	Benefits	Value	Frequency
Reduction of ticket price	€ 14.400,00	per year	Visibility of ads	Not quantified	
Total	€ 14.400,00		Total	€ -	
Yearly balance	€ -14.400,00				
Fixed investment	€ -				

Figure 32: Financial Dashboard BM04

8. BM05- Green and Comfortable Commuting to Inner City

8.1. Business model description

Managing traffic and related infrastructure can be particularly challenging in cities with old or historic city-centres with highly dense and protected areas. Many of such cities have reached to the limits of their transport infrastructure and resource capacity, while being confronted with rising car traffic to and from its commuter belt, which also requests more parking space. One remedy to address this problem is to endorse public transportation. The business model takes the inner-city commuter traveling by car on a daily basis as the customer of the mobility solution. The business model has been built on the idea of offering incentives for the commuters to make a model shift when approaching the condensed inner city and park their vehicles in the outskirts and make use of public transportation to the final travel destination in inner-city.

Accordingly, the value proposition to the commuters is green and comfortable commuting in the city (through a service bundle of urban parking availability, mode and trip time advice and in-vehicle signage). As unnecessary cruising for parking is avoided, an eco-friendlier commuting experience can be created. Moreover, through optimized mode and trip time advice, users can reach their desired destination without the hassle of stress when driving and searching for a suitable parking space.

The blueprint business model is given in Figure 33.

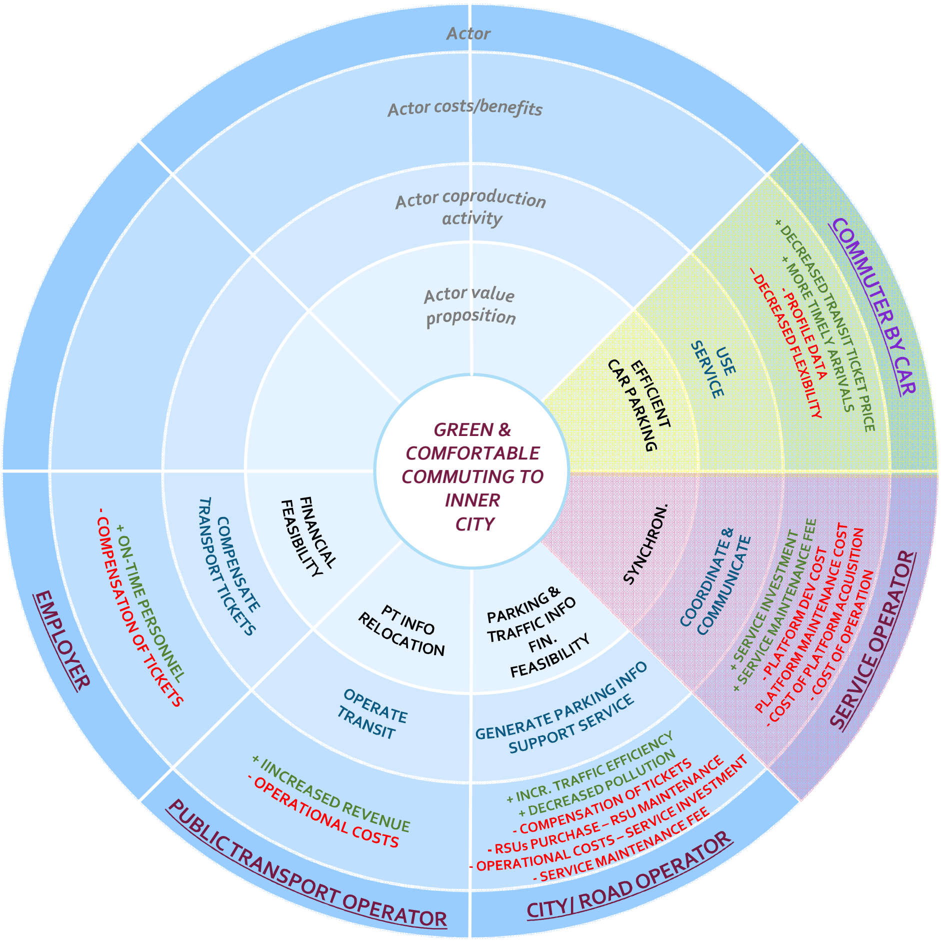

Figure 33: Business model radar for BM05 - Green and Comfortable Commuting to Dense City

8.2. Involved Actors

Commuter by car (customer)

The commuter by car can use the service through in-vehicle signage to receive advice and guidance on parking space availability. The feasibility of the value in use offered through the business model depends on the adoption of the service and the behaviour of the car commuter whilst using the service. Therefore, the value proposition of the car commuter is the *effective use of the service*, or *efficient parking of car*. If commuters by car are not stimulated to park outside of the inner city, the value in use decreases. This value proposition is offered through using the service (effectively). The car commuter will benefit from reduced tariffs or even free transit tickets through using the service. Moreover, as optimized and adequate advice is given on where to park and how to reach the desired location, an *increased comfortable commuting* experience should be obtained. To use the service, the users have to present location and destination data, which may *impact their privacy*. Moreover, the user is bounded to public transport arrival and departure times, which may *impact his or her travel freedom*.

Service operator (orchestrator)

The service operator is responsible for generating parking advice and guidance, as well as providing mode and trip time advice on how to reach the desired location of the user from the parking space. Therefore, the service operator must take care of integrating and synchronizing these streams of data in order to provide the service. Therefore, the value proposition of the service provider is the *synchronization of data*. This is conducted through the co-production activity of coordinating the different streams of data and communicating with related business model stakeholders. As the model is subsidized through the municipality, the service operator benefits from *a fixed service investment* as well as a *variable maintenance fee*, whereas *operating costs* (related to the development and maintenance of the service platform) are incurred to do so.

City / road operator (core partner)

The city / road operator will benefit from the service solution offered in the business model through *decreasing pollution* as traffic congestion is decreased and car drivers do not unnecessarily cruise around the city to find a suitable parking space. Moreover, the city will benefit from *increased traffic efficiency*. However, these benefits depend on the adoption of the service amongst commuters by car. Therefore, to stimulate this adoption, the municipality can finance the service, allowing the service to be offered for free to car drivers. Therefore, the value proposition of the municipality is to offer *financial feasibility* of the service, which is conducted through subsidizing the service. In addition to this, the city is also responsible for generating the traffic and parking information required to support the service. Therefore, the city also has a value proposition related to (the generation of) *parking & traffic info*, generated through the co-production activity of generating parking information. As a result of these efforts, the city incurs costs related to the purchase / development and maintenance of the RSUs required to generate parking and traffic data, as well as operational costs related to data integration and communication. Lastly, to stimulate the deployment and operation o the service, the city pays a fixed service investment and a variable maintenance fee to the service operator.

Transit operator (core partner)

The transit operator (or public transport operator) takes care of transporting car commuters from their parking space to their desired destination. As such, the value proposition of the transit operator is the *relocation of commuters*. This is conducted through the coproduction activity of operating the transit. As car commuters are stimulated to take public transport to reach their desired location in the city, the transit operator will benefit from increased revenues, as more customers are attracted. Costs for offering tickets at reduced rates (as part of the service solution) are covered through the joint efforts

Employer (enriching partner)

Use of the service enables commuters to travel more comfortable and timelier to their desired location in the inner city, which in turn is also beneficial for the employers in the inner city (as personnel can arrive timelier and may experience less stress in doing so). These benefits may stimulate employers to actively contribute to the business model scenario in terms of financial incentives for using the service (e.g., contributing to a reduction of the ticket prices). Accordingly, the value proposition for the employer is to stimulate the *financial feasibility* of the business model scenario, which is achieved through the co-production activity of *compensating the transport tickets* for commuters. As a result, the employer incurs costs related to the compensation of transit tickets paid for its employees (to stimulate its employees to park at the outskirts of the city and take public transport to arrive at their location), but in return is able to benefit from increased on-time personnel through service use.

8.3. Operational scenario

A number of technology services supports the solution; the commuter is provided with urban parking availability and mode & trip time advice (see Sections 19.1 and 19.12, respectively, for more information about these services) through an application on their smart mobile devices, while green (light) priority is applied for public transportation vehicles (see Sections 19.7 for more information about this service). Urban parking availability provides parking information to its users to make informed decisions about available parking places around the vicinity or destination of the user. This is supported by the mode & trip time advice that aims to provide the commuter with an optimal itinerary with public transportation or other modes for the rest of their commuting path. In addition, the solution is supported by providing priority to public transportation vehicles in roads (through traffic signalling) to help reduce their travel time.

The users that commute into downtown are directed by the application to the nearest suitable parking location in the outskirt, considering dynamic traffic, location, parking, and public transportation data. Accordingly, the application provides advice for the onwards to commuters desired travel destination. Depending on the traffic conditions in downtown, the application offers special incentives to commuters, such as free or reduced-tariff public transportation.

In this service scenario, in addition to reduced travel costs due to free or discounted tickets, the commuters can also benefit from increased comfort, as unnecessary cruising for parking is reduced. The city benefits from decreased pollution and less congestion. The transit operator offers relocation of commuters from the car parks to the vicinity of their final destination, while the road operator ensures a certain level of traffic priority for public transportation vehicles. It provides the parking information and benefits from a better usable road system at the cost of managing or operating the road infrastructure.

The operational scenario is depicted in the form of a choreography diagram respectively in in Figure 34. The choreography diagram includes an initial set-up scenario for the C-ITS solution (the flow at the top of the figure) and the operational scenario (the flow at the bottom of the figure). *(Appendix-C describes how a choreography diagram can be interpreted.)*

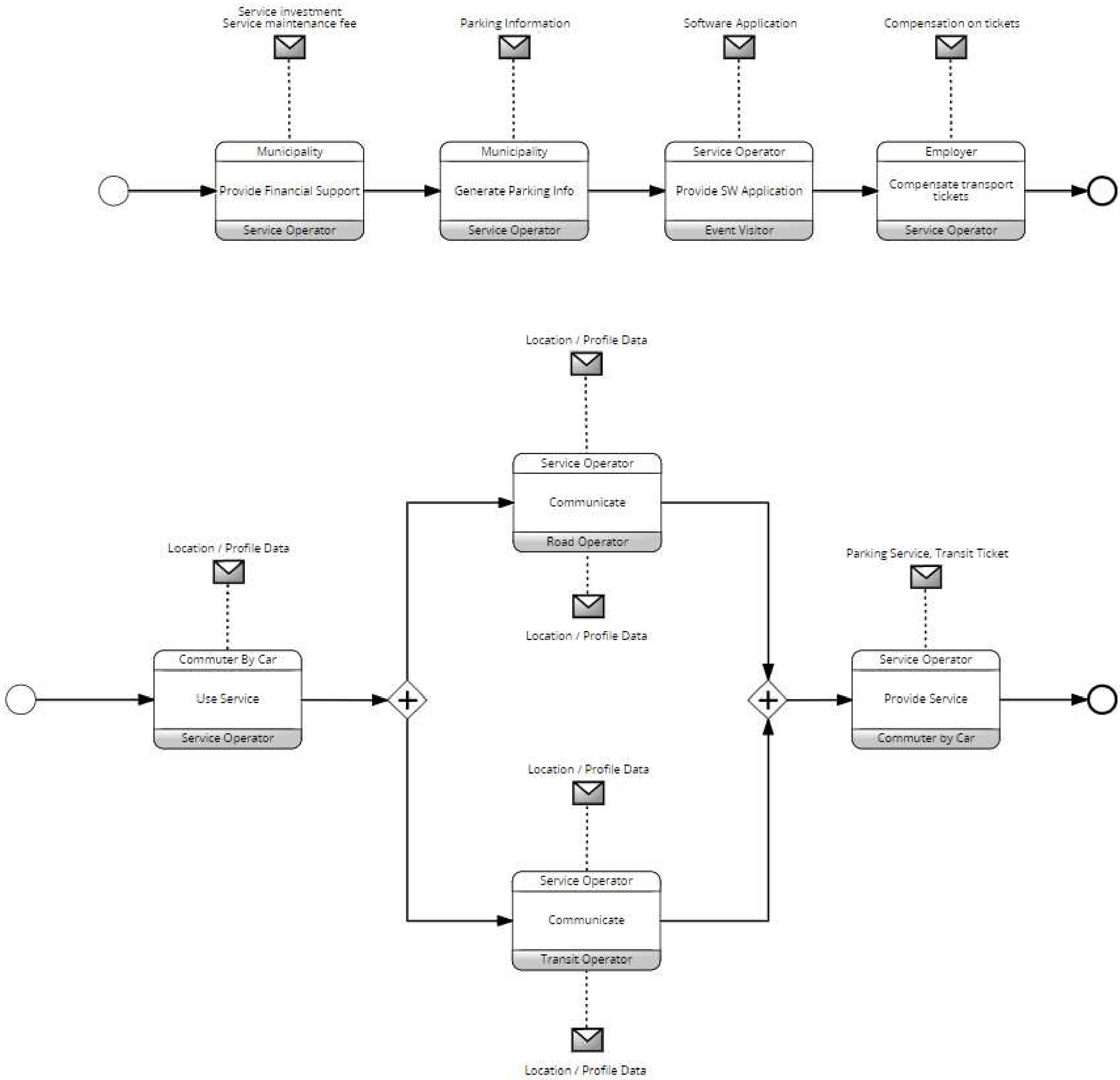

Figure 34: Choreography diagram for BM06- Green and Comfortable Commuting to Dense City

8.4. BM05 Business Case Analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM05 is depicted by means of the value capture diagram presented in Figure 35. As illustrated, BM05 consists of 5 actors, of which 4 (namely the service provider, city / road operator, public transport operator and employer) generate financial or tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the commuter by car (although receiving a discount through use of the service) generates largely intangible costs and benefits (e.g., largely related to perceptions and difficult to quantify or express in financial terms). Accordingly, we omit the perspective of the commuter by car for the financial analysis of the business case for the business model design, and focus on the remaining 4 parties.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that city / road operator pays a fixed *service investment* as well as a variable *service maintenance fee* to the service provider to implement and operate the service. In addition, as mentioned, both the employer and city / road operator are involved for the incentivization scheme, compensating a percentage of the discounts offered to commuters by car (for which logically these percentages can be altered). As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that each of the actors also generate costs and benefits which are not based on exchange and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions, traffic efficiency and fuel consumption).

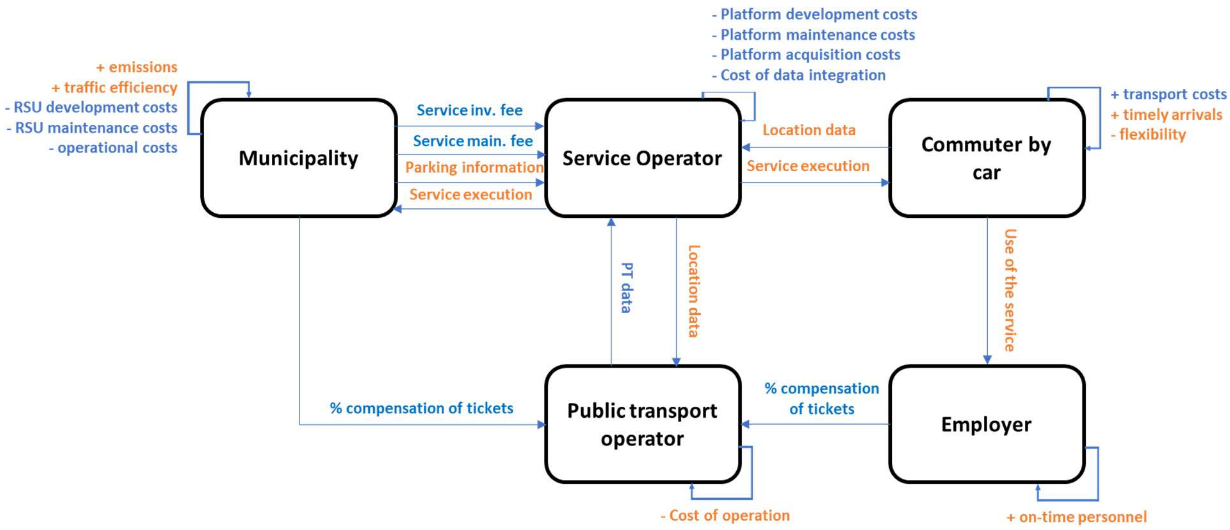

Figure 35: Value Capture Diagram for BM05 – Green and Comfortable Commuting to Inner City

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 6) have been used. These values are based on the deployments in the *Bordeaux, France deployment site* where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 6: Parameter settings used for BM05 business case analysis

Parameter description	Frequency	Value
Number of users of service	Per month	2000 users
Cost of platform development	Fixed	22.000 euro[43]
Cost of platform maintenance	Per month	700 euro[43]
Cost of platform purchase	Fixed	15.000 euro[43]
Cost of data integration	Per month	100 euro[43]
Mark-up percentage (service provider)	Fixed	30%[43]
Average public transport infrastructure spending per service user (Bordeaux)	Per month	10 euro[43]
Average ticket spending (Bordeaux)	Per month	20 euro[43]
Average distance of an inner city trip	Fixed	20 km

[43] *Information obtained through Video-Conference – Bordeaux [16-03-2021]*

Average number of trips per service user	Per month	20
Average fuel consumption	Fixed	0,073 L/km[44]
Emissions ton CO_2 per liter of fuel	Fixed	0,00264 [45]
Monetary value of a ton CO_2	Fixed	€84,00[46]
Percentage reduction in travel time per user	Fixed	10%
Average travel time (commute)	Fixed	60 minutes
Percentage average speed increase as a result of service	Fixed	1%
Average speed in Bordeaux	Fixed	30 km/h[43]
Value of time savings	Per minute	€0,40[47]
Number of road users in inner city of Bordeaux	Per month	10.000
Number of parking areas in Bordeaux supported	Fixed	50[43]
Number of RSUs	Per parking area	5[43]
Cost of development / purchase of RSU	Fixed	2000 euro[43]
Cost of maintenance of RSU	Per month	100 euro[43]
Cost of data collection	Per month	100 euro[43]
Percentage of compensation offered on discounts tickets (city)	Fixed	90%
Percentage of compensation offered on discounts tickets (employer)	Fixed	10%

8.4.1. Service operator

The detailed tab for the service provider is illustrated in Figure 36. One can see that the costs for the service operator pertain to the development, maintenance and acquisition of the platform needed to deploy the service, as well as the costs of data integration to provide end-users with the correct information based on their requests in the service application. In this business scenario, the purchase of the platform (outsourced through a software provider) and subsequent development are concretized as fixed investments of €22.000 and €15.000 respectively. To maintain the platform and to support the integration and transformation of data, monthly costs equal to €700 and €100 are incurred. These costs are compensated through the service investment and fees received from the city. Here, a mark-up of 30% is considered, resulting in a fixed service investment received from the city of €48.100 (kickstarting the business model and its operation) as well as a variable service maintenance fee (to continue operation of the service) of €12.480.

	variable	fixed	frequency	value	yearly value
Operating costs	€ 9.600,00	€ 37.000,00			
Cost of platform development			fixed	€ 22.000,00	€ 22.000,00
Cost of platform maintenance			per month	€ 700,00	€ 8.400,00
Cost of purchase platform			fixed	€ 15.000,00	€ 15.000,00
Cost of integration of data			per month	€ 100,00	€ 1.200,00

	Variable	fixed	frequency	value	yearly value
Service operation	€ 12.480,00	€ 48.100,00			
Service investment (from city)			fixed	€ 48.100,00	€ 48.100,00
Percentage markup			fixed	30%	
Service maintenance fee (from city)			per month	€ 1.040,00	€ 12.480,00
Percentage markup			fixed	30%	

Figure 36: Breakdown of costs and benefits for service operator

8.4.2. Public transport operator

The detailed tab for the public transport operator is illustrated in Figure 37. For the public transport operator, the costs pertain to the increased user volume, generating additional infrastructure or operational expenses. Assuming that on average per user per month €10,00 is spent, an expected increase of the user base by 2000 users would yield additional costs for the public transport operator equal to €240.000 per year. Logically, the increase in user base also generates benefits for the public transport operator in terms of increased revenue. Assuming in this business scenario an average ticket price spending of €20 per month, this would equate to an increase in revenue of €480.000 per year (which would more than compensate the increased overhead incurred).

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[44] *https://www.osti.gov/pages/servlets/purl/1339511#:~:text=The%20average%20fuel%20consumption%20is,regulation%20(EU%2C%202009), an average consumption of 7.32 litres per 100 km*
[45] *https://ecoscore.be/en/info/ecoscore/co2*
[46] *https://www.en-former.com/en/metric-ton-co2-cost/*
[47] *http://www.salaryexplorer.com/salary-survey.php?loc=861&loctype=3 46.000 average per year, equalling 0,40ct per minute.*

	Variable	fixed	frequency	value	yearly value
Infrastructure costs	€ 240.000,00				
Increase in infrastructure maintenance			per month	€ 20.000,00	€ 240.000,00
Number of users			fixed	2000	
Average infrastructure spending per user			per month	€ 10,00	

	Variable	fixed	frequency	value	yearly value
Increased revenue	€ 480.000,00				
Additional ticket sales (resulting through an increase in users)			per month	€ 40.000,00	€ 480.000,00
Number of users			per month	2000	
Average ticket price			per month	€ 20,00	

Figure 37: Breakdown of costs and benefits for public transport operator

8.4.3. Employer

The detailed tab for the employer is presented in Figure 38. As indicated for the business model design, the employer contributes to the financial viability of the business model by covering part of the ticket expenditures for its commuters. Assuming that a 15% decrease in ticket price (in addition to the effects of using the service for the commuter by car) would spark an increase of 2000 users, and assuming that the employer covers 5% of this compensation offered, the employer incurs costs equal to €24.000 per month. However, as commuters arrive timelier at work (and likely are less stressed), the employer in turn benefits from stimulating the service for its employees. If employees arrive timelier (assuming a decrease in travel time of 10%), benefits of €57.600 per year can be reached for its employees.

	Variable	fixed	frequency	value	yearly value
Compensation of tickets	€ 24.000,00				
Compensation of tickets purchased			per month	€ 2.000,00	€ 24.000,00
Number of users			per month	2000	
Average price of tickets			fixed	€ 20,00	
% of compensation for tickets			fixed	5%	

	Variable	Fixed	frequency	value	yearly value
Value of employees arriving timely	€ 57.600,00				
Value of employees arriving timely			per month	€ 4.800,00	€ 57.600,00
Percentage of reduction in travel time			fixed	10%	
Number of users			per month	2000	
Average travel time			fixed	60	
Value of minutes saved per user			fixed	€ 0,40	

Figure 38: Breakdown of costs and benefits for the employer

8.4.4. City

The detailed tab for the city is presented in Figure 39. One can see that the costs for the city relate to installing and maintaining the RSUs / infrastructure to monitor parking availability, stimulating the use of the service through ticket compensation, the costs incurred for collecting the parking data, as well as the costs paid to the service provider to operate the service. For Bordeaux, 50 parking areas can be considered, for which parking availability can be monitored per area using 5 RSUs. For this scenario, the acquisition cost of an RSU is set to €2.000 (fixed), whereas the maintenance cost of RSUs is set to €100 (per month). As a result, the fixed costs for outfitting the parking areas equates to €500.000, whereas the variable costs equate to €25.000 per year. In addition to the service investment and service maintenance fee paid to the service operator, the city also may take part of the compensation offered to commuters to stimulate the service use. Here, a 10% compensation is offered (in addition to the 5% offered by the employer), resulting in compensation of ticket costs equal to €48.000 per year. Lastly, the city incurs costs related to generating and integrating the parking data, such that the service provider is able to communicate this to end-users. Here, a yearly cost of €1.200 is incurred.

		Variable	fixed	frequency	value	yearly value
Compensation of tickets		€ 48.000,00				
Compensation of tickets purchased				per month	€ 4.000,00	€ 48.000,00
	Number of users			per month	2000	
	Average price of tickets			fixed	€ 20,00	
	% of compensation for tickets			fixed	10%	
Service operation		€ 12.480,00	€ 48.100,00			
Service investment (from city)				fixed	€ 48.100,00	€ 48.100,00
	Percentage markup			fixed	30%	
Service maintenance fee (from city)				per month	€ 1.040,00	€ 12.480,00
	Percentage markup			fixed	30%	
Cost of equipment acquisition			€ 500.000,00			
Cost of equipment acquisition				fixed	€ 500.000,00	€ 500.000,00
	Number of parking areas			fixed	50	
	Number of RSUs needed per parking area			fixed	5	
	Cost of an RSU			fixed	€ 2.000,00	
Cost of equipment maintenance		€ 25.000,00				
Cost of equipment maintenance				fixed	€ 25.000,00	€ 25.000,00
	Number of parking areas			fixed	50	
	Number of RSUs needed per parking area			fixed	5	
	Cost of RSU maintenance			fixed	€ 100,00	
Cost of data collection		€ 1.200,00				
Cost of data collection				per month	€ 100,00	€ 1.200,00

		Variable	fixed	frequency	value	yearly value
Value of decrease in pollution		€ 155.409,41				
Value of decrease in fuel consumption				per month	€ 12.950,78	€ 155.409,41
	Number of users (modal shift)			per month	2000	
	Average distance of an inner city trip			fixed	20	
	Average number of trips			per month	20	
	Average fuel consumption (L/km)			fixed	0,07	
	tCO2 emissions per litre of fuel			fixed	0,00264	
	Value of tCO2 emissions			fixed	€ 84,00	
Value of improved traffic efficiency		€ 384.000,00				
Value of improved traffic efficiency				per month	€ 32.000,00	€ 384.000,00
	Percentage average speed increase (km/h)			fixed	1%	
	Average speed in Bordeaux			fixed	30	
	Road users in inner city of Bordeaux			per month	10000	
	Average number of trips			per month	20	
	Average trip distance in Bordeaux (km)			fixed	20	
	Value of minutes saved per road user			fixed	€ 0,40	

Figure 39: Breakdown of costs and benefits for city

In terms of benefits, use of service stimulates commuters by car to park their car at the outskirts of the city and travel by public transport to their work. This generates benefits for the city in terms of decreased pollution as well as improvements with regards to traffic efficiency. For decreased pollution, assuming that an average trip distance in the inner city (e.g., back and forth) accounts to 20 kilometers, and that on average a commuter undertakes 20 trips per month, benefits of up to €155.409,41 can be achieved (considering the value of tCO_2 to be €84,00[46] and the average consumption to be 0,073 L/km[44]). In terms of traffic efficiency, extrapolating for the current users as opposed to the potential amount of road users in Bordeaux (here considered as 10.000 road users), an increase of 1% driving speed could yield benefits up to €384.000 per year for Bordeaux.

8.4.5. Results of Business Case Analysis

Based on the selected parameter settings, the business case results as presented in Figure 40 are obtained. One can see that under the current parameter settings, all actors in the business model design generate a positive financial outcome. Starting from the city / road operator, the benefits generated with respect to decreased pollution and increased traffic efficiency (amounting €46,949,76 and €120.000 respectively) offset the variable costs incurred related to compensating the discounts of the public transport tickets (currently set at 90% of the ticket price), the service maintenance fee paid to the service provider (for operating and sustaining the service) and the costs related to RSU maintenance and data collection. It should be noted however that the costs for the installation or implementation of the RSUs significant. In the current scenario, a payback time of 10 years should be considered before the city breaks-even on these initial investments (assuming the RSUs have no residual value after use). In case the RSUs can be used for different purposes (or be owned by private parking operators), this would further decrease the costs for the city / road operator. Even though the service investment provides some room for what-if analysis (as the service provider in the current scenario generates a negative fixed investment, e.g., a fixed benefit), this exchange offers limited impact to improve the scenario for the city.

The employer benefits from employees arriving timely at work, which offsets the compensation currently paid for discounts on public transport tickets (assuming a percentage of 10%). The public transport operated generates increased revenue as through use of the service a modal shift from car to bus / tram is stimulated (at the expense of increased operational costs). The service provider compensates the costs of developing and maintaining the platform application, as well as the costs of data integration through the benefits received from the city.

Service Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Cost of platform develop	€ 22.000,00	fixed	Service investment	€ 48.100,00	fixed
Cost of platform purchase	€ 15.000,00	fixed	Service maintenance fee	€ 12.480,00	per year
Cost of platform mainten	€ 8.400,00	per year			
Cost of data integration	€ 1.200,00	per year			
Total	€ 9.600,00		**Total**	€ 12.480,00	
Yearly balance	€ 2.880,00				
Fixed investment	€ -11.100,00				

Public transport operator

Costs	Value	Frequency	Benefits	Value	Frequency
Infrastructure costs	€ 240.000,00	per year	Increase revenue	€ 480.000,00	per year
Total	€ 240.000,00		**Total**	€ 480.000,00	
Yearly balance	€ 240.000,00				
Fixed investment	€ -				

Employer

Costs	Value	Frequency	Benefits	Value	Frequency
Compensation of tickets	€ 24.000,00	per year	Timely employees	€ 57.600,00	per year
Total	€ 24.000,00		**Total**	€ 57.600,00	
Yearly balance	€ 33.600,00				
Fixed investment	€ -				

City / Road Operator

Costs	Value	Frequency	Benefits	Value	Frequency
Compensation of tickets	€ 48.000,00	per year	Value of decreased pollution	€ 155.409,41	per year
Service investment	€ 48.100,00	fixed	Increased traffic efficiency	€ 384.000,00	per year
Service maintenance fee	€ 12.480,00	per year			
Cost of equipment acquisition	€ 500.000,00	fixed			
Cost of maintenance equipment	€ 25.000,00	per year			
Cost of data collection	€ 1.200,00	per year			
Total	€ 86.680,00		**Total**	€ 539.409,41	
Yearly balance	€ 452.729,41				
Fixed investment	€ 548.100,00				

Figure 40: Financial Dashboard BM05

9. BM06 - Safe Driving Experience via In-Vehicle Warning Services

9.1. Description

Increasing safety of road users, including drivers, vulnerable road users (VRUs), such as pedestrians and cyclists, is among the key focus areas of C-ITS services. In-vehicle warning services for drivers[48] (such as motorcycle approaching indication, warning system for VRUs, emergency vehicle warning, slow or stationary traffic warning, road works warning) aim to alert the driver in the case of a potential adverse incident to enhance driver's and other road network users' safety. This bundle of services is particularly valuable when the driver is distracted, visibility is poor, or traffic density is high. In order to operate the service, data is collected on the speed and location of the driver through sources such as road-side units, vehicles, and VRUs. In case a potential incident is detected, the service emits a warning signal to the driver (or automatically takes control) to avoid an incident. In turn, this improves the safety of both the driver and other traffic users (e.g., pedestrians, cyclists, powered two-wheeler riders, and other VRUs).

The value proposition of the service solution is a safe and comfortable travelling experience for vehicle drivers (through in-vehicle warning signage). As warning signage facilitates vehicle drivers to timely react to dangerous scenarios, and as such increases the awareness of the driver, accidents with other traffic users can be avoided. In turn, this should create a more safe and comfortable travel experience for vehicle drivers.

The blueprint business model is given in Figure 41.

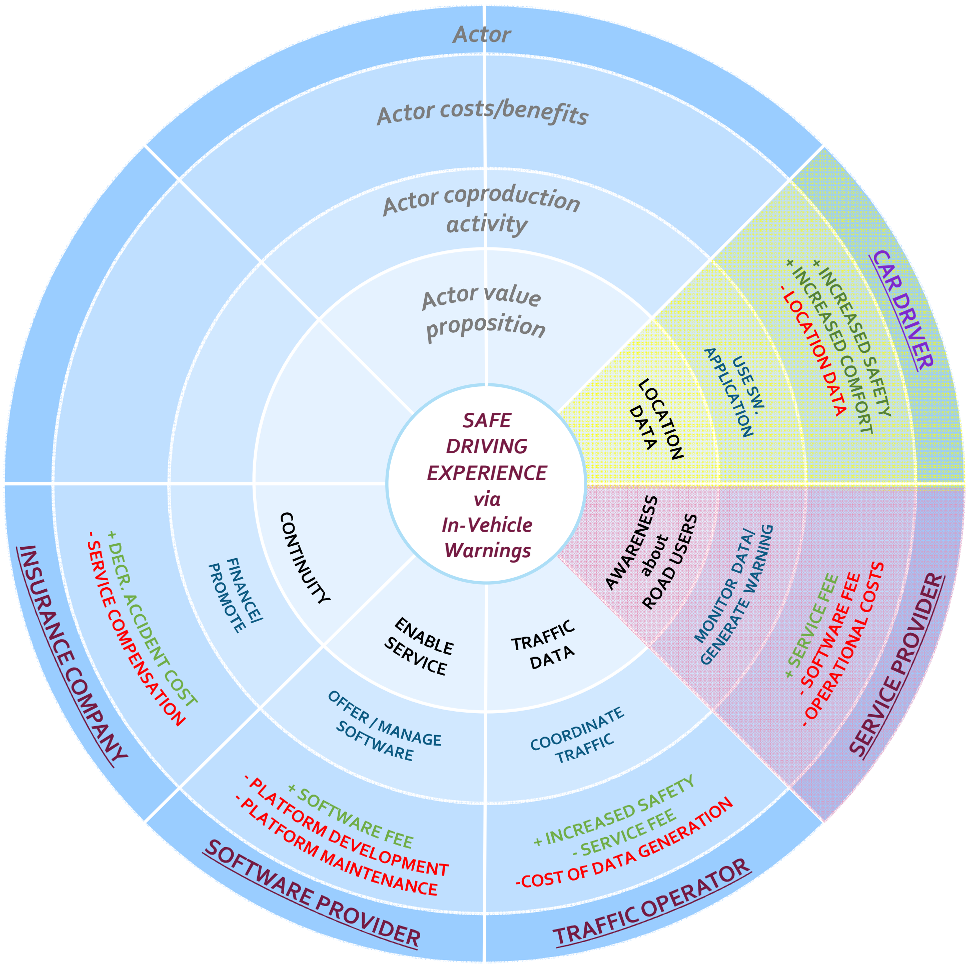


Figure 41: Business model radar for BM06 - Safe Driving Experience via In-Vehicle Warning Services

[48] *In-vehicle warning services that are bundled under the theme of "Safe Driving Bundle" include the following:*
S04- Road works warning (more information in Section 19.2)
S05- Road hazard warning (Section 19.3)
S06- Emergency vehicle warning (Section 19.4)
S07- Signal violation warning (Section 19.5)
S08- Warning system for pedestrian (Section 19.6)
S16- Emergency brake light (Section 19.14)
S18- Slow or stationary vehicle warning (Section 19.16)
S19- Motorcycle approaching Indication (Section 19.17)
S20- Blind-spot detection/warning (Section 19.18)
Please refer to deliverable D2.2 [42] *for more information.*

9.2. Actors in business model

Car driver (customer)

The car driver is warned by the service bundle (through in-vehicle warning signage) if a dangerous scenario (e.g., collision with VRUs or other traffic users) is bound to occur. To assess whether a dangerous scenario may occur, the service bundle tracks the speed, location and direction of the vehicle driver. Therefore, the value proposition of the vehicle driver is to present *location* or *user data*. This data is generated through the coproduction activity of using the software application. As the vehicle driver is signalled if a collision is bound to occur, *the number of accidents* can be *decreased* (or even avoided). The car driver benefits moreover from *increased comfort*, as driving becomes less stressful (especially in high-traffic environments). However, in order for the service to be effective, the vehicle driver has to present *location data*, which may influence the privacy of the user.

Service provider (orchestrator)

The service provider is responsible for operating the service, specifically generating the warning signals if dangerous scenarios are bound to occur. As a result, the vehicle driver can benefit from increased awareness and improve his or her decision making. Therefore, the value proposition of the service provider is to create *awareness (of other traffic users)*. This is generated through the coproduction activity of monitoring the user and traffic data and consequently generating the warning. For providing the service, the service provider receives an *operating fee (or service fee)*, whereas the service provider pays a *software fee* to the software provider to use a dedicated software platform and subsequently be able to provide the service to car drivers. In addition to this software fee, the service provider incurs costs related to operating the service (e.g., the generation and sending of events for car drivers with respect to use of the service).

Traffic operator (core partner)

The traffic operator (or in case integrated, the city / municipality) is responsible for generating and distributing traffic data, specifically with regards to the behaviour of VRUs in the vicinity of the vehicle driver. This data consequently is integrated by the service provider to provide warning signage when needed. As such, the value proposition of the traffic operator is the *traffic data*, which is generated through *coordinating or monitoring the behaviour of VRUs*. This may also be extended to other traffic users to further enhance the service. The traffic operator benefits from *less accidents* as awareness of the driver is increased, which in turn will also lead to an *improved image of traffic* within the city or municipality. For generating the required traffic data, *operational costs* (*cost of data generation*) are incurred.

Software provider (core partner)

The software provider must take care of providing and maintaining the platform on which the service will operate. As such, the value proposition of the software provider is *enabling the service*, which is conducted through the coproduction activity of *providing and managing the softwar*e. The software provider receives *a fee* from the service provider to provide and maintain the software, whereas *manufacturing costs* are incurred to maintain and update the software.

Insurance company (core partner)

In order to stimulate the adoption of the service, the service can be offered for free to vehicle drivers. To compensate for the costs incurred of offering the service, insurance companies can act as sponsoring parties, as use of the service can reduce the amount of road accidents that may occur, in turn decreasing the amount of insurance compensations to be paid. The insurance companies can stimulate the use of the service by *subsidizing* the service to increase adoption amongst vehicle drivers (e.g., making sure the service can be offered for free). As the number of potential accidents is reduced, the municipality benefits from decreased insurance pay-outs with regards to road accidents (which may validate financing the service solution).

9.3. Operational scenario

In the operational scenario, the *service provider* collects data from road-side units, vehicle drivers, and the other traffic users (VRUs, powered two-wheeler riders, etc.) and uses it to offer *vehicle driver* a safe travelling experience through warning signage. The application tracks the location, direction, and speed of the vehicle driver. The application can interact with roadside units (RSUs) which collect data on the behaviour of VRUs in the vicinity of the vehicle driver. The service consequently analyses, based on both streams of data, whether a dangerous scenario may occur (e.g., a potential collision between the vehicle driver and other traffic users). If such a scenario is bound to occur, the service alerts the driver through an in-vehicle warning signage in the case of a potential incident with other traffic users. As such, the service enhances the awareness of the vehicle driver and improves his or her decision making. In turn, this should lead to a safer travel experience, as potential accidents can be avoided.

The driver is offered a safe travelling experience via the safe driving bundle (in-vehicle warning services). The bundled service is offered by the service provider through an application either on a smartphone or on an on-board unit. When necessary, the application signals a warning to facilitate the car driver to react timely and adapt to the environment. As such, it enhances the awareness of the driver and improves his or her decision making. This leads to a safer and more comfortable travel experience, as potential accidents can be avoided.

The traffic operator (or in case integrated, the city/municipality) is responsible for generating and distributing traffic data, including those related to the behaviour of other road users in the vicinity of the driver. This data is consequently integrated by the service provider to provide warning signage when needed. The traffic operator benefits from less accidents as awareness of the driver is increased. The software provider maintains the platform on which the service operates and receives a fee from the service provider.

Financing for the business model is supported mainly by insurance companies, which distribute and promote the service over vehicle drivers in their insurance package. As the likelihood of an accident that involves vehicles equipped with the bundle is lesser, the insurance companies are less frequently required to pay out to compensate for incurred damages. Moreover, this may also lead to an improved corporate image, as the insurance company actively invests in social responsibility. Part of these retained profits consequently can be invested in ensuring that the service remains financially feasible to maintain these benefits.

The operational scenario is depicted in the form of a choreography diagram respectively in Figure 42. The choreography diagram includes an initial set-up scenario for the C-ITS solution (the flow at the top of the figure) and the operational scenario (the flow at the bottom of the figure). *(Appendix-C describes how a choreography diagram can be interpreted.)*

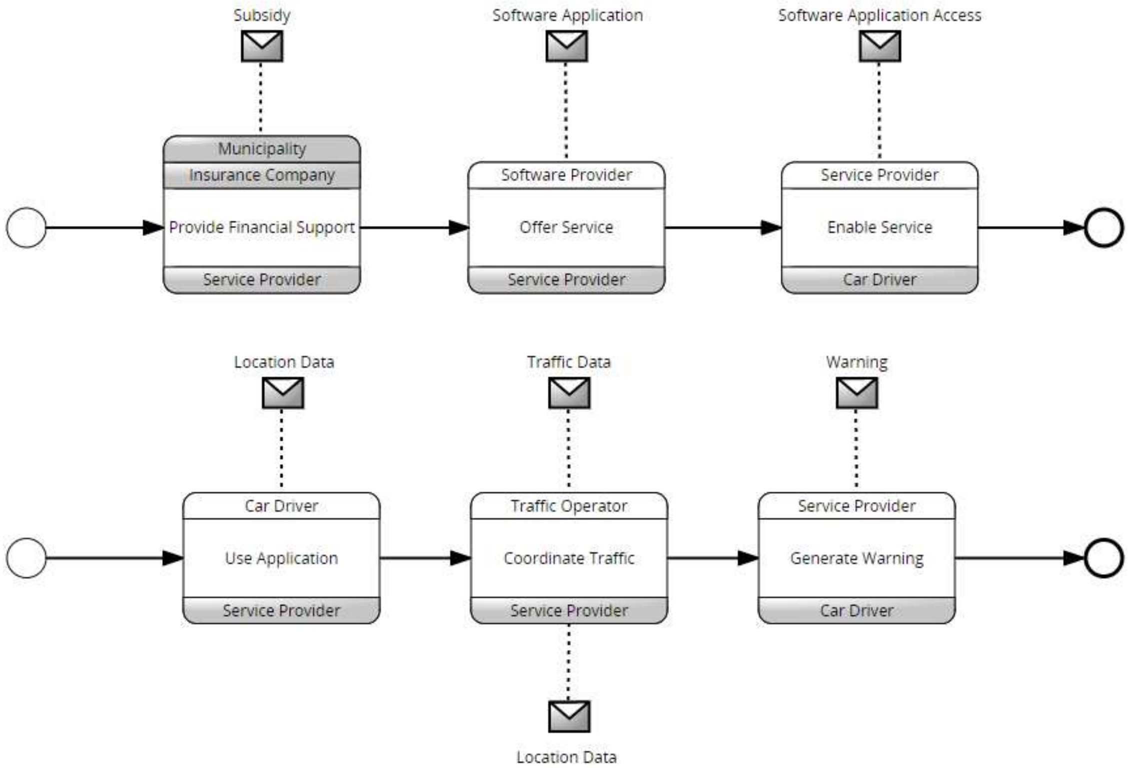


Figure 42: Choreography diagram for BM06 - Safe Driving Experience via In-Vehicle Warning Services

9.4. BM06 Business Case Analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM07 is depicted by means of the value capture diagram presented in Figure 43. As illustrated, BM06 consists of 5 actors, of which 4 (namely the service provider, traffic operator, software provider and insurance company) generate financial or tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the car driver generates largely intangible costs and benefits (e.g., largely related to perceptions and difficult to quantify or express in financial terms). Accordingly, we omit the perspective of the commuter by car for the financial analysis of the business case for the business model design, and focus on the remaining 4 parties.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that traffic operator pays a *service fee* to the service provider to implement and operate the service. In addition, the insurance company may further complement this fee through a *service compensation* for the service provider. Lastly, the service provider pays a *software fee* to the software provider to support the development and maintenance of the platform. In addition, as mentioned, both the employer and city / road operator are involved for the incentivization scheme, compensating a percentage of the discounts offered to commuters by car (for which logically these percentages can be altered). As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that each of the actors also generate costs and benefits which are not based on exchange, and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions, traffic efficiency and fuel consumption).

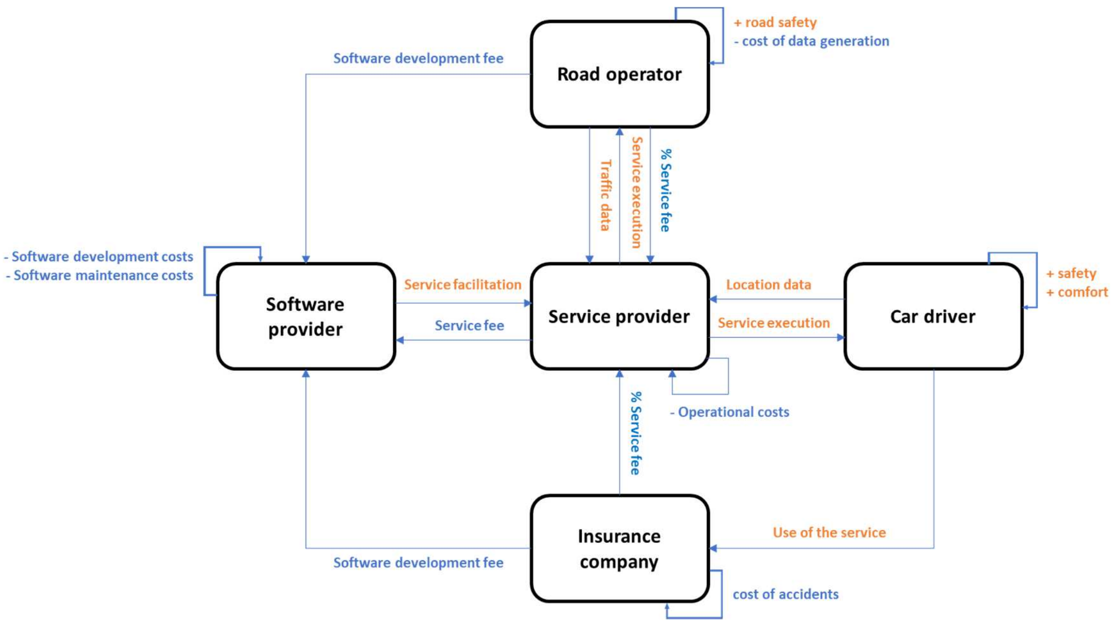


Figure 43: Value Capture Diagram BM06 – Safe Driving Experience

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 7) have been used. These values are based on the deployments in the *Barcelona, Spain deployment site* where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 7: Parameter settings used for BM06 business case analysis

Parameter description	Frequency	Value
Number of service users	Per month	2000 users
Software fee	Per month	1000 euro[49]
Service fee (paid by city)	Per month	2500 euro
Service fee (paid by insurance company)	Per month	2500 euro
Compensation of software development costs (paid by city)	Fixed	120.000 euro
Compensation of software development costs (paid by insurance company)	Fixed	120.000 euro
Platform monitoring costs	Per month	500 euro[49]
Platform development costs	Fixed	240.000 euro[49]
Platform maintenance costs	Per month	1000 euro[49]
Decrease in traffic accidents as a result of service use	Fixed	10,3%[50]
Average number of road users in Barcelona	Fixed	1.240.000 users[51]

[49] *Information obtained through Video-Conference – Barcelona [11-03-2021]*
[50] *D2.1 Ex-Ante Cost Benefit Analysis*
[51] *https://www.statista.com/statistics/776832/volume-medium-from-traffic-daily-in-the-access-to-the-city-from-barcelona/#:~:text=At%20the%20end%20of%20the,per%20day%20compared%20to%202014.*

Parameter description	Frequency	Value
Number of slight road accidents (road users)	Per year	11630 times[52]
Number of serious accidents (road users)	Per year	202 times[52]
Number of fatal accidents (road users)	Per year	22 times[52]
Cost of a slight road accident	Fixed	1000 euro[53]
Cost of a serious road accident	Fixed	300.000 euro[53]
Cost of a fatal road accident	Fixed	2.800.000 euro[53]
Percentage of road accidents cost compensated by insurance	Fixed	50%

9.4.1. Service Provider

The detailed tab for the service provider is presented in Figure 44. One can see that the costs for the service provider pertain to the use of the software platform, as well as the operational costs for offering the service to the end-users. In terms of the use of the software platform, a software fee is paid (€2000 per month). With regards to the operational costs for the service (platform monitoring), a cost of €500 per month is considered. With respect to the benefits for the service provider, a service fee is received through the joint efforts of the insurance company and city. As can be seen, for this scenario, a total service fee of €60.000 per year is received (of which 50% is covered by the city and 50% by the insurance company).

	Variable	fixed			
Operating costs	€ 30.000,00				
			frequency	value	yearly value
Use of software platform (software fee + maintenan			per month	€ 2.000,00	€ 24.000,00
Costs of platform monitoring			Per month	€ 500,00	€ 6.000,00

	Variable	fixed			
Service fee	€ 60.000,00				
			frequency	value	yearly value
% of service fee received from city			per month	€ 2.500,00	€ 30.000,00
% of service fee received from insurance company			per month	€ 2.500,00	€ 30.000,00

Figure 44: Breakdown of costs and benefits for service provider

9.4.2. Software provider

The detailed tab for the software provider is presented in Figure 45. The software provider incurs costs related to the development and maintenance of the software platform, which is used by the service provider to operate the service. For this scenario, these costs and benefits are set to €240.000 fixed and €1000 per month respectively. As explained for the service provider, the software provider receives a compensation for its efforts in terms of a software fee (set at €500 per month or €6000 per year). In addition, the software provider receives a (fixed) platform development compensation. Again, a similar structure is considered here, for which both the city and insurance company compensate €120.000 to stimulate the development and deployment of the service (enough to compensate the initial expenses made).

	Variable	fixed			
Platform development costs		€ 240.000,00			
			frequency	value	yearly value
Platform development costs			fixed	€ 240.000,00	€ 240.000,00
	Variable	fixed			
Platform maintenance costs	€ 12.000,00				
			frequency	value	yearly value
Platform maintenance costs			per month	€ 1.000,00	€ 12.000,00

	Variable	fixed			
Software fee	€ 24.000,00				
			frequency	value	yearly value
Use of software platform + support (service provider)			per month	€ 2.000,00	€ 24.000,00
	Variable	fixed			
Development		€ 240.000,00			
			frequency	value	yearly value
% of development cost received from city			fixed	€ 120.000,00	€ 120.000,00
% of development cost received from insurance			fixed	€ 120.000,00	€ 120.000,00

Figure 45: Breakdown of costs and benefits for software provider

9.4.3. Insurance Company

The detailed tab for the insurance provider is presented in Figure 46. For the insurance provider, the costs pertain to the percentage of service fee paid to the service provider (which has been set to 50% of the total amount, e.g., €2500 per month or €30.000 per year). In addition, the insurance company compensates part of the costs incurred by the software provider for the development of the service platform (€120.000). Stimulated use of the service in return however benefits the insurance company in terms of a reduction in road accidents, requiring the insurance company to pay less in terms of insurance compensation. To calculate this reduction in road accidents, we draw upon the number of accidents on average in Barcelona, categorized based on their severity (e.g., fatal accidents, severe accidents and light accidents). For Barcelona, these statistics 11630 light accidents, 202 severe accidents and 22 fatal accidents. If we consider the costs for such accidents to be in the

[52] *https://media-edg.barcelona.cat/wp-content/uploads/2020/01/21130134/2020_01_28-Balanc%CC%A7-Sinistralitat-V.-post-pre%CC%80via-1.pdf*
[53] *https://www.swov.nl/en/facts-figures/factsheet/road-crash-costs*

magnitude of €1000, €300.000 and €2.800.000 per category respectively, extrapolating from the potential number of road users in Barcelona (1.240.000 road users) against the current amount of users (10000 for this business case), and considering that impact of service use on road safety is roughly 10% and that the insurance compensates 50% of the expenses made, the savings would amass €55.582,62, which would offset the variable costs incurred.

	Variable	fixed			
Service fee	€ 30.000,00				
			frequency	value	yearly value
% of service fee paid to service provider			per month	€ 2.500,00	€ 30.000,00
	Variable	fixed			
Development service		€ 120.000,00			
			frequency	value	yearly value
Development cost			fixed	€ 120.000,00	€ 120.000,00

		Variable	Fixed			
Value of reduction of accidents		€ 55.582,62				
				frequency	value	yearly value
Value of reduction of accidents				fixed	€ 55.582,62	€ 55.582,62
	Number of light road accidents road users			per year	11630	
	Cost per light accident			fixed	€ 1.000,00	
	Number of serious road accidents road users			per year	202	
	Cost per serious accident			fixed	€ 300.000,00	
	Number of fatal accidents road users			per year	22	
	Cost per fatality			fixed	€ 2.800.000,00	
	Current number of service users			per year	10000	
	Amount of road users in Barcelona			per year	1240000	
	Potential decrease in accidents as a result of service			fixed	10%	
	Percentage compensated by insurance			fixed	50%	

Figure 46: Breakdown of costs and benefits for insurance company

9.4.4. City

The detailed tab for the city is illustrated in Figure 47. Similar to the insurance provider, the city pays a variable service fee and a fixed development fee to the service provider and software provider respectively and captures benefits in terms of the reduction of accidents. However, in contrast to the insurance provider, the benefits for the city consider the total economic costs that are saved due to a reduction in accidents. Accordingly, the city amasses benefits as a result of service usage equal to €111.165,24.

	Variable	fixed			
Service fee	€ 12.000,00				
			frequency	value	yearly value
% of service fee received from city			per month	€ 1.000,00	€ 12.000,00
	Variable	fixed			
Development service		€ 120.000,00			
			frequency	value	yearly value
Development cost			fixed	€ 120.000,00	€ 120.000,00

		Variable	Fixed			
Value of reduction of accidents		€ 111.165,24				
				frequency	value	yearly value
Value of increased safety				fixed	€ 111.165,24	€ 111.165,24
	Number of slight road accidents road users			per year	11630	
	Cost per slight accident			fixed	€ 1.000,00	
	Number of serious road accidents road users			per year	202	
	Cost per serious accident			fixed	€ 300.000,00	
	Number of fatal accidents road users			per year	22	
	Cost per fatality			fixed	€ 2.800.000,00	
	Current number of users of service			per year	10000	
	Potential number of users for service			per year	1240000	
	Potential decrease in accidents as a result of serv			fixed	10%	

Figure 47: Breakdown of costs and benefits for city

9.4.5. Results of Business Case Analysis

Based on the selected parameter settings, the business case results as presented in Figure 48 are obtained. One can see that based on the selected parameter settings, all actors for the business model design obtain a positive financial outcome. The expected reduction in accidents (e.g., slight, serious, and fatal, amounting in this scenario €16.059,60) because of the service offset the service fee paid by the city to the service provider. A similar case can be observed for the insurance company, for which the savings on financial compensation because of road accidents are able to compensate the €500 service fee that is currently paid to the service provider. Although the software provider has an upfront investment cost of €1000 euro, the software fee received from the service provider is significant and generates a yearly profit that is large enough to compensate this investment within a single year (e.g., a payback time of 1 year). A similar case currently is generated for the service provider, that through the service fees received from the insurance company and city can offset the costs incurred for operating the service. Here, even without the contribution of the insurance company (i.e., €6000 yearly), the service provider would still be able to generate a viable service scenario. Note that if the user base for the service increases, the operating costs for the service provider are likely to increase, requiring the city to increase the service fee accordingly (considering the effects on road safety generated due to use of the service).

Service Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Use of platform service	€ 24.000,00	per year	% of service fee received from city	€ 30.000,00	per year
			% of service fee received from insurance (	€ 30.000,00	per year
Total	€ 24.000,00		**Total**	€ 60.000,00	
Yearly balance	€ 36.000,00				
Fixed investment	€ -				

Software Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Platform development	€ 240.000,00	fixed	Use of platform service	€ 24.000,00	per year
Platform maintenance (	€ 12.000,00	per year	Software development fee	€ 240.000,00	fixed
Total	€ 12.000,00		**Total**	€ 24.000,00	
Yearly balance	€ 12.000,00				
Fixed investment	€ -				

Insurance Company

Costs	Value	Frequency	Benefits	Value	Frequency
% of service fee paid to servic	€ 30.000,00	per year	Value of reduction of accidents	€ 55.582,62	per year
Development of service	€ 120.000,00	fixed			
Total	€ 30.000,00		**Total**	€ 55.582,62	
Yearly balance	€ 25.582,62				
Fixed investment	€ 120.000,00				

City

Costs	Value	Frequency	Benefits	Value	Frequency
% of service fee paid to	€ 12.000,00	per year	Value of reduction of accidents	€ 111.165,24	per year
Development of service	€ 120.000,00	fixed			
Total	€ 12.000,00		**Total**	€ 111.165,24	
Yearly balance	€ 99.165,24				
Fixed investment	€ 120.000,00				

Figure 48: Financial Dashboard BM06

10. BM07 - Reliable and Efficient Public Transport Operation

10.1. Description

Traffic information services, such as road hazard warning, road works warning, or traffic jam warning, aim to inform the driver in a timely manner, allowing the driver to be better prepared for upcoming obstacles, to improve his or her decision making while driving, and to take necessary actions in advance. These services can either be offered through road-side units (RSUs) or combined with in-vehicle signage services. The service provider can collect data on road hazards, road works and traffic jams, as well on real-time behaviour of traffic users. Consequently, through either the cellular network or RSUs, this data can be integrated and communicated to traffic users, allowing them to improve their decision making.

The business model blueprinted above, aims to support reliable and efficient public transportation for public transport operators through the operators' bundle of C-ITS services[54]. The bundle includes services, such as road hazards warning, road works warning, GLOSA, and slow or stationary vehicle warning. Traffic data is integrated by the service provider and consequently communicated to the public transport operator as well as other traffic users. Other traffic users can use this traffic data to improve their decision making whilst driving. This may include slowing down to adequately cope with hazardous scenarios further up the road or taking a different route instead to avoid a hazardous scenario or traffic congestion. As other traffic users are more informed of upcoming traffic and may potentially change their behaviour leading to decrease in congestion.

As public transportation vehicles (e.g., busses) are typically confined to standard routes and are not allowed to deviate from these routes, arrival and trip times for busses would become more predictable and reliable as well, considering real-time traffic data. As such, bus operators can offer more reliable trip and arrival times to their customers (commuters by transit).

To further improve the efficiency of transportation for bus operators, the service provider moreover can collect usage data for vehicles from commuters by transit. This data can be communicated to bus operators, showing when peak or high demand periods for busses may occur. Consequently, the operator can adapt the fleet to match these demand patterns, improving efficiency of the service. Commuters who adhere to their proposed travel plans can receive a discount in order to stimulate this behaviour.

The value proposition of the business model is to make public transport more desirable by increasing the timeliness of the public transport services. By making use of this increased priority, especially for the behind-the-schedule vehicles, public transport operators provide increased punctuality for their public transportation services. As a result, the cities will benefit from increased use of public transportation, decreased pollution, and an improved image as the punctuality of the public transportation increased.

The blueprint business model is given in Figure 49.

[54] *Operators Bundle for reliable and efficient service provisioning include the following:*
S04- Road works warning (more information in Section 19.2)
S05- Road hazard warning (Section 19.3)
S09- Green priority (Section 19.7)
S10- GLOSA (Section 19.8)
S12- Flexible infrastructure (Section 19.10)
S13- In-vehicle signage (Section 19.11)
S15- Probe Vehicle Data (Section 19.13)
S18- Slow or Stationary Vehicle Warning (Section 19.16)
Please refer to deliverable D2.2 [42] *for more information.*

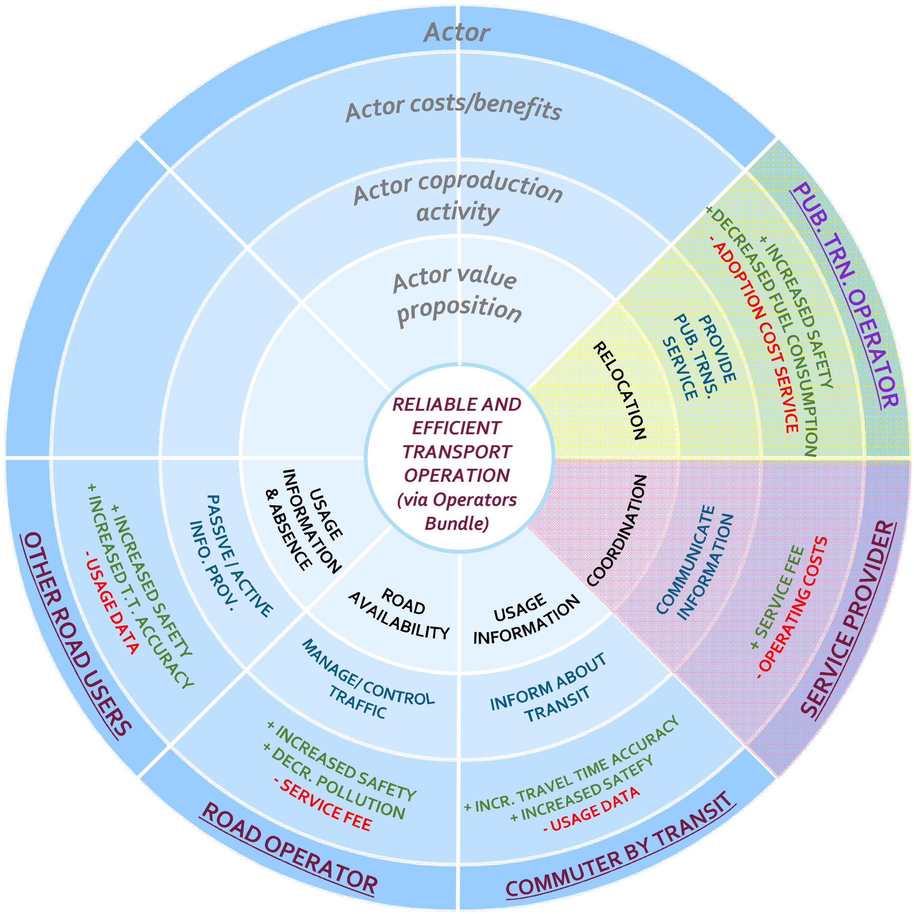


Figure 49: Business model radar for BM07 - Reliable and Efficient Public Transport Operation

10.2. Involved Actors

Public transport operator (customer)

The public transport operator receives real-time traffic information for its vehicles to improve road decision making, as well as on some occasions green priority to improve the schedule of lagging public transport vehicles. Accordingly, the service enables public transport operators to increase punctuality for its public transportation services. As the punctuality increases, the number of citizens choosing public transport as the main mode of transportation will increase. This in turn will lead to an increase in the *operating costs* but to compensate that, the public transport operator benefits from *fuel savings* and *lessened driver stress* in return.

Service provider (orchestrator)

In order to provide green priority, the green priority request including the identification information of the public transport vehicle can be published via on-board software applications in the vehicle, as well as any data on current traffic conditions (such as road incidents or traffic jams). Consequently, service providers can pick up this information and generate events for public transport operators such that they can timely react to these occurrences. The value proposition for service provider is c*oordination and communication* of these data streams. The service provider benefits from a *service fee* which is paid by the road operator to stimulate the service. For collecting and integrating the necessary data to operate the service, *operational costs* are incurred.

Road operator (core partner)

To compensate for the costs incurred of offering the service, the road operator can act as a sponsoring party. The road operator as such *subsidizes* the service to promote the service for the citizens, such that the application can be obtained at a low or free tariff. Through adoption of the service by public transport operators, the road operator can benefit from *increased road safety* (as public transport can make more informed decision making) and decrease pollution (as public transport operators can adopt a more balanced speed). In addition, the punctuality of the public transportation increases, which could further improve the image for the road operator / municipality. This in turn may validate offering *financial support* (in terms of a *service fee* paid to the service provider) to participate in the business model.

Commuter by transit (core partner)

The commuter by transit can improve punctuality for public transport operators through indicating their travel itineraries, informing the public transport operators when and where they desire to take public transport. This facilitates the public transport operator in turn to communicate more reliable (punctual) arrival times for such commuters, in turn improving their public transport experience. Accordingly, the value proposition of the commuter by transit is the provisioning of *usage information*, which is generated through the co-production activity of *informing public transport* (through use of the application) on their respective travel itineraries. In return for doing so, the commuter by transit benefits from increased travel time accuracy (as public transport operators are aware of the travel itineraries of commuters), whereas commuters travelling by bus / tram also benefit from increased safety (due to the use of the operator bundle). As a cost, the commuter by transit is required to present *usage / profile data*.

Other road users (enriching partner)

To further enhance the effectiveness of the service, other road users can make use of the application as well, sharing their location to further refine updates on traffic information and road accidents, as well acting on information received through the application. Through real-time information received, other road users can improve their decision making with regards to driving speed and route, in turn further improving road conditions. Accordingly, the value proposition for other road users is the *usage information (*such as *location data*) as well as *adherence to advice* given through the service. This is generated through the co-production activity of providing information through use of the service. Through use of the service, other road users can benefit from increased safety on the roads and increased travel time accuracy (following advice presented to them). As a cost, these road users are required to present locational data.

10.3. Operational scenario

In the operational scenario, the traffic manager offers increased priority for the public transport vehicles operated by the public transport operator. By making use of this increased priority, especially for the behind-the-schedule vehicles, public transport operator provides increased punctuality for its public transportation services. To compensate the increased operating costs, the public transport operator benefits from fuel savings and lessened driver stress in return. The technology infrastructure required for the service is installed and maintained by the technical service provider. In return for the operational costs related to its co-production activities, the technical service provider benefits from the subsidy support provided by the city municipality. Similarly, the traffic manager will benefit from a potential market advantage and better market position in return for the operational costs resulting from the prioritization of the traffic lights.

The operational scenario is depicted in the form of a choreography diagram in Figure 50. *(Appendix-C describes how a choreography diagram can be interpreted.)*

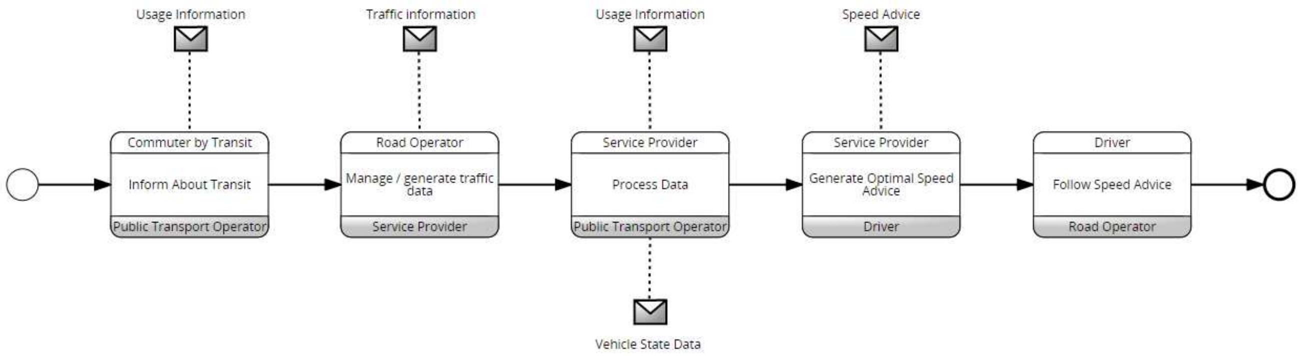


Figure 50: Choreography diagram for BM07 - Reliable and Efficient Public Transport Operation

10.4. Business Case Analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM07 is depicted by means of the value capture diagram presented in Figure 51. As illustrated, BM07 consists of 5 actors, of which 3 (namely the service provider, road operator and public transport operator) generate financial or tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the commuter by transit and other road users generates intangible costs and benefits (e.g., largely related to perceptions and difficult to quantify or express in financial terms). Accordingly, we omit the perspective of the commuter by transit and other road users for the financial analysis of the business case for the business model design and focus on the remaining 3 parties.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that traffic operator pays a *service fee* to the service provider to implement and operate the service. In addition, the insurance company may further complement this fee through a *service compensation* for the service provider. Lastly, the service provider pays a *software fee* to the software provider to support the development and maintenance of the platform. In addition, as mentioned, both the employer and city / road operator are involved for the incentivization scheme, compensating a percentage of the discounts offered to commuters by car (for which logically these percentages can be altered). As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that each of the actors also generate costs and benefits which are not based on exchange and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions, traffic efficiency and fuel consumption).

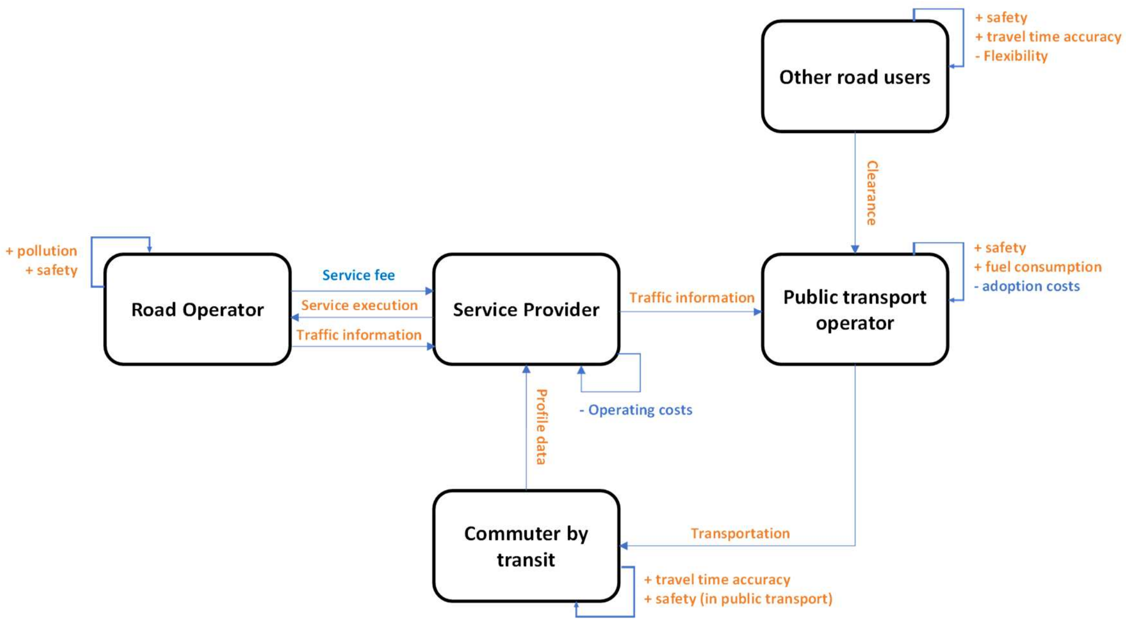


Figure 51: Value capture diagram for BM07 - Reliable and Efficient Transport Operation

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 8) have been used. These values are based on the deployments in *Newcastle, United Kingdom deployment site* where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 8: Parameter settings used for BM07 business case analysis

Parameter description	Frequency	Value
Number of public transport users	Per month	1000 users
Cost of platform development	Fixed	10.000 euro
Cost of platform maintenance	Per month	500 euro
Cost of data integration	Per month	250 euro
Service fee (paid by road operator)	Per month	1000 euro
Adopting costs of service (public transport operator)	Per month	500 euro

Parameter description	Frequency	Value
Number of slight road accidents involving public transport Newcastle	Per year	67[55]
Number of slight road accidents involving public transport Newcastle	Per year	7[55]
Number of fatal road accidents involving public transport Newcastle	Per year	2[55]
Cost of slight road accident for the road operator / city	Fixed	3.000 euro[56]
Cost of slight road accident for the road operator / city	Fixed	300.000 euro[56]
Cost of slight road accident for the road operator / city	Per year	2.800.000 euro[56]
Cost of slight road accident for the public transport operator	Fixed	1000 euro
Cost of serious road accident for the public transport operator	Fixed	20.000 euro
Cost of fatal road accident for the public transport operator	Fixed	1.000.000 euro
Potential number of public transport service users available	Fixed	100.000
Potential decrease in accidents as a result of service use	Fixed	6%[57]
Decrease in fuel consumption as a result of service use	Fixed	1%[58]
Average amount of kilometers driven	Per month	4500 kilometers
Average fuel consumption	Fixed	0,45 L/km[59]
Emissions ton CO_2 per liter of fuel	Fixed	0,00264 [60]
Monetary value of a ton CO_2	Fixed	€84,00[61]
Fuel price (Newcastle)	Fixed	€1,46[62]

10.4.1. Service Provider

The detailed tab for the service provider is presented in Figure 52. The costs for the service provider in this scenario are related to the development and maintenance of the platform required to operate the service, as well as costs related to the service operation itself (e.g., data integration). For this scenario, the platform development costs have been set to €10.000 (fixed), whereas the platform maintenance costs have been set to €500 per month. Lastly, the data integration costs are set to €250 per month.

	variable	fixed	frequency	value	yearly value
Platform costs	€ 6.000,00	€ 10.000,00			
Cost of platform development			fixed	€ 10.000,00	€ 10.000,00
Cost of platform maintenance			per month	€ 500,00	€ 6.000,00
	variable	fixed			
Cost of data integration	€ 3.000,00				
Cost of data integration			per month	€ 250,00	€ 3.000,00

	Variable	fixed	frequency	value	yearly value
Service fee	€ 12.000,00				
Service fee received from road operator / city			per month	€ 1.000,00	€ 12.000,00

Figure 52: Breakdown of costs and benefits for service provider

With regards to the benefits for the service provider, a service fee is received from the road operator / city to operate the service and to compensate its expenses. In this scenario, the service fee is set to €1.000 per month (e.g., a yearly income of €12.000), enough to compensate the variable expenses incurred.

10.4.2. Public transport operator

The detailed tab for the public transport operator is illustrated in Figure 53. One can see that in terms of costs, adoption costs are considered for the public transport operator, related to stimulating its public transport drivers to adequately use the service, and supporting its drivers in using the service. There costs are currently set to €500 per month. Through use of the service, public transport drivers are better informed of road issues or accidents ahead, in turn improving their safety as well as enabling drivers to reduce their fuel consumption. To quantify the increased safety for public transport operators, we draw upon the number of accidents involving public transport in Newcastle, categorizing accidents based on fatal, severe, and light accidents. The corresponding numbers are 67 light, 7 severe and 2 fatal accidents. Extrapolating for the current number of service users in this scenario (2000) against the total number of road users in Newcastle (100.000), and

[55] *https://www.gateshead.gov.uk/media/3813/Road-Traffic-Collisions-Report-2015/pdf/Road-Accidents-Report-2015.pdf?m=636440118878800000*

[56] *https://www.swov.nl/en/facts-figures/factsheet/road-crash-costs*
[57] *D2.1 Ex-Ante Cost Benefit Analysis, upper bound effect of included C-ITS services on safety*
[58] *D2.1 Ex-Ante Cost Benefit Analysis, upper bound effect of included C-ITS services on fuel consumption*
[59] *https://www.energy.gov/sites/default/files/2014/03/f8/deer07_erkkila.pdf, 45L on average per 100km for different European cities*
[60] *https://ecoscore.be/en/info/ecoscore/co2*
[61] *https://www.en-former.com/en/metric-ton-co2-cost/*
[62] *https://www.anwb.nl/vakantie/reisvoorbereiding/euro-95-benzineprijzen-europa [29-04-2021]*

assuming use of the service is expected to decrease the occurrence of road accidents by 6%, this facilitates one to calculate the expected value of increased safety if the costs of accidents per category for the public transport operator are known. In this scenario, these costs correspond to €1000 per light accident, €20.000 per severe accident and €100.000 per fatal accident. As a result, benefits of €1.842 per year can be generated. With regards to fuel consumption, assuming a that a reduction in fuel consumption of 1% can be expected due to the service usage, and further assuming that on average a public transport operator drives 4500 kilometers per month under an average consumption of 0,45 L/km[57], savings of up to €177.390 in fuel consumption can be expected.

	Variable	fixed	frequency	value	yearly value
Adoption cost	€ 6.000,00				
Increased operating costs as a result of using the service			per month	€ 500,00	€ 6.000,00

		Variable	fixed	frequency	value	yearly value
Value of increase safety		€ 1.842,00				
Value of increased safety				fixed	€ 1.842,00	€ 1.842,00
	Number of slight road incidents Public transport			per year	67	
	Cost for public transport operator			fixed	€ 1.000,00	
	Number of serious road incidents public transport			per year	7	
	Cost for public transport operator			fixed	€ 20.000,00	
	Number of fatal incidents public transport			per year	1	
	Cost for public transport operator			fixed	€ 100.000,00	
	Current number of public transport service users			per year	1000	
	Potential number of public transport service users			per year	10000	
	Potential decrease in accidents as a result of service			fixed	6%	

		Variable	fixed	frequency	value	yearly value
Value of decrease in fuel consumption		€ 177.390,00				
Value of decrease in fuel consumption				per month	€ 14.782,50	€ 177.390,00
	Number of users for the service			per year	1000	
	Decrease in fuel consumption as a result of service			fixed	1%	
	Average fuel consumption (L/km)			fixed	0,45	
	Average kilometers driven			per month	4500	
	Fuel price			fixed	€ 1,46	

Figure 53: Breakdown of costs and benefits for public transport operator

10.4.3. Road operator

The detailed tab for the road operator is illustrated in Figure 54. As mentioned for the service provider, the road operator compensates the service provider (through a service fee) to stimulate the service deployment. Analogously to the service provider, this service fee has been set to €1000 per month (e.g., €12.000 per year).

With regards to the benefits, both the increased road safety as well as the decrease in pollution are considered. With regards to road safety, as similar approach is considered as explained for the public transport operator. However, in contrast to the public transport operator, the entire economic costs are considered for the road operator. Accordingly, €47.406 as a result of decreased accidents can be considered for the road operator (assuming different costs per category of accidents as opposed to the public transport operator).

	Variable	fixed	frequency	value	yearly value
Service fee	€ 12.000,00				
Service fee paid to service provider			per month	€ 1.000,00	€ 12.000,00

		Variable	fixed	frequency	value	yearly value
Value of road safety		€ 47.406,00				
Value of increased safety				fixed	€ 47.406,00	€ 47.406,00
	Number of slight road incidents Public transport			per year	67	
	Cost of light accident city			fixed	€ 3.000,00	
	Number of slight road incidents Public transport			per year	7	
	Cost of severe accident city			fixed	€ 300.000,00	
	Number of fatal accidents public transport			per year	2	
	Cost of fatal accident city			fixed	€ 2.800.000,00	
	Current number of public transport service users			per year	1000	
	Potential number of public transport service users			per year	10000	
	Potential decrease in accidents as a result of service			fixed	6%	

		Variable	Fixed	frequency	value	yearly value
Value of decreased pollution		€ 53.887,68				
Value of decreased pollution				per month	€ 4.490,64	€ 53.887,68
	Number of users for the service			per year	1000	
	Decrease in fuel consumption as a result of service			fixed	1%	
	Average fuel consumption (L/km)			fixed	0,45	
	Average kilometers driven			per month	4500	
	Average emissions of tCO2 per litre diesel			fixed	0,00264	
	Monetary value of 1 tCO2			fixed	84	

Figure 54: Breakdown of costs and benefits for road operator

With regards to decreased pollution, the effect of (a decrease in) fuel consumption on CO_2 emissions is considered. Considering again a reduction of fuel consumption because of the service use of 1%, and further assuming average emissions per liter fuel of 0,00264 tCO_2 and a value of a ton CO_2 of €84,00, the value of decreased pollution can be quantified as €53.887,68.

10.4.4. Results of Business Case Analysis

Based on the selected parameter settings, the business case results as presented in Figure 55 are obtained. One can see that based on the selected parameter settings, all actors for the business model design obtain a positive financial outcome. The service provider, although required to make a fixed investment of €10.000 to develop the platform, generates a significant yearly profit amounting €3.000, meaning that the service provider can break even in its initial investments in roughly 3-4 years. On the other hand, the road operator, although in this scenario required to offer compensation for the service (through a service fee of €12.000 on a yearly basis), can offset its incurred costs through the benefits received in terms of road safety and decreased pollution as a result of the service. The same holds for the public transport operator, for which use of the service may decrease its fuel consumption (€40.500 yearly) and may decrease the costs of busses or trams being involved in road accidents (€1.842 yearly). These benefits significantly offset and incurred operational costs (related to the adoption and installation of the service).

Given the beneficial scenario for the road operator, the road operator may elect to increase the service fee (from €1000 to at most €1400) to further improve the viability for the service provider. In this case, the service provider would break even in roughly 1 year.

Service Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Cost of platform develop	€ 10.000,00	fixed	Service fee	€ 12.000,00	per year
Cost of platform mainten	€ 6.000,00	per year			
Cost of data integration	€ 3.000,00	per year			
Total	€ 9.000,00		**Total**	€ 12.000,00	
Yearly balance	€ 3.000,00				
Fixed investment	€ 10.000,00				

Public Transport Operator

Costs	Value	Frequency	Benefits	Value	Frequency
Increased operating costs	€ 6.000,00	per year	value of increased safety	€ 1.842,00	per year
			value of decreased fuel consumption	€ 182.250,00	per year
Total	€ 6.000,00		**Total**	€ 184.092,00	
Yearly balance	€ 178.092,00				
Fixed investment	€ -				

Road Operator

Costs	Value	Frequency	Benefits	Value	Frequency
Service fee	€ 12.000,00	per year	Value of decrease in pollution	€ 53.887,68	per year
			Value of road safety	€ 47.406,00	per year
Total	€ 12.000,00		**Total**	€ 101.293,68	
Yearly balance	€ 89.293,68				
Fixed investment	€ -				

Figure 55: Financial Dashboard BM07

11. BM08 - Efficient Freight Delivery in an Urban Areas

11.1. Description

Freight transport is essential in urban areas for replenishing stocks of various merchandise in shops and markets and delivering parcels and other supplies to offices in centre locations. However, despite the critical need, the freight delivery in urban areas has several adverse effects, such as increased traffic congestion and disruption, and increased air and noise pollution. These effects are amplified in city centres where providing sufficient loading and unloading spots is problematic, yet not managed effectively. The business model targets at the issues regarding traffic disruption due to urban freight transportation. It does so by bringing structure into the management of parking process and capacity during urban freight delivery using the parking availability service.

The objective is to offer efficient freight delivery in the urban areas with the aim to decrease related traffic disruptions and incidents. The model is enabled by an application where parking operator offers time and availability information about parking spots that are allocated for freight delivery, and truck drivers of logistics companies or of specific associations indicate their urban delivery information through reservation. Such parking management schemes are necessary to bring a structure into the related process. However, these schemes are effective only when all relevant stakeholders collaborate closely, and the system is operated and monitored effectively.

This business model targets at the issues regarding traffic disruption due to urban freight transportation. It does so by bringing structure into the management of parking process and capacity during urban freight delivery using the parking availability service (more information about this service is available in Section 19.1). The blueprint business model is given in Figure 56.

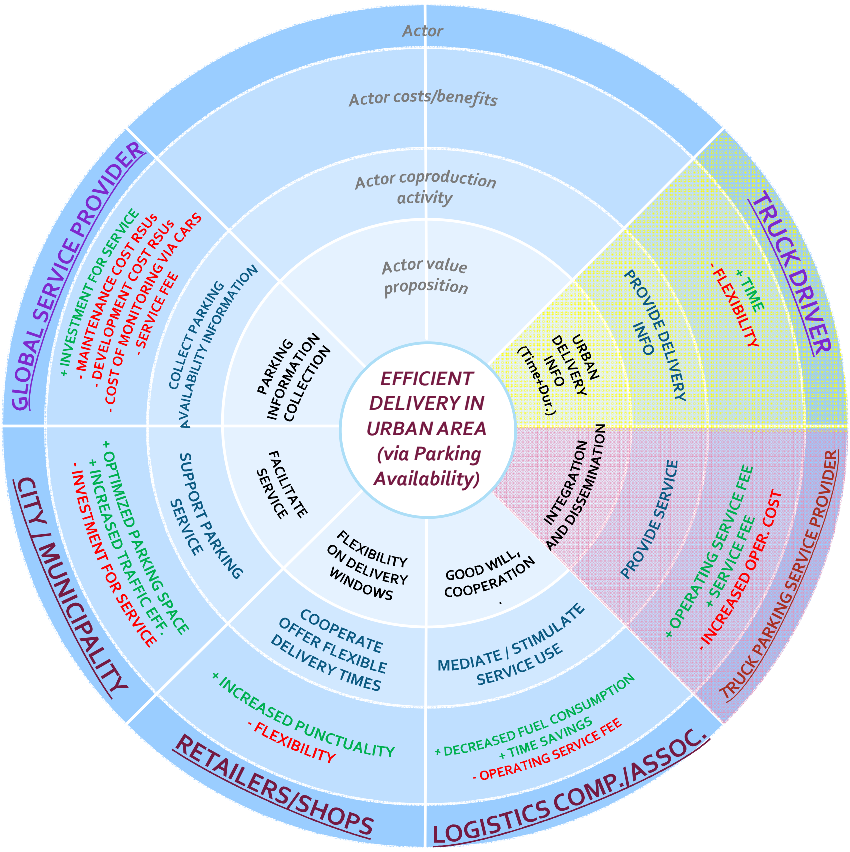


Figure 56: Business model radar for BM08 - Efficient Freight Delivery in an Urban Areas

11.2. Involved Actors

Truck Driver (customer)

The Truck Driver reserves a parking spot for a specific time and duration using the system provided by the Parking Operator. Therefore, the value proposition of the truck driver is to present information with regards to their delivery schedule (to which they must adhere). This decrease in flexibility and the need for an additional reservation step is compensated through *free and guaranteed parking*. Moreover, this will also save the truck drivers *time* to find a suitable parking location.

Truck Parking Service Provider (orchestrator)

The truck parking service provider facilitates the process by a reservation system, which potentially receives data from plate-reading sensors in parking slots. For truck drivers to reserve a parking spot, the truck parking service provider offers truck drivers *the time slots for reserving a parking spot (and monitors when trucks should leave*) through the system. *Increased costs* due to the additional operations for running the system are compensated through the *service fee* paid by the global service provider (responsible for deploying parking as well as related mobility services in the city), as well as an *operating service fee* from the logistics companies for using the service.

Municipality (core partner)

The City Municipality typically owns the parking spots and identifies those that are suitable for loading/unloading in urban areas. Therefore, the municipality contributes to the co-created value by *providing data* with regards to which *parking spots are available* (which is forwarded to the parking operator). In addition, the city facilitates the service operations executed by the global service provider (enabling the global service provider to deploy the service). To do so, the municipality contributes to the business model design through paying an *investment for the service* to the global service provider. In return, it benefits from *better traffic management* and potentially *decreased traffic disruptions*.

Logistics Companies/ Driver Associations (enriching partner)

Logistics Companies or the Associations (of which the drivers are member) are enriching parties in the business model, which *mediate between drivers and municipality*, endorsing the use of the reservation system, to benefit from reliable and timely parking in the inner city. Therefore, their value proposition is to create *cooperation* amongst truck drivers to use the reservation system and to stimulate its subsequent use. Through participation in the business model design, the logistics companies benefit from increased fuel consumption and time savings with regards to parking in dense urban settings for its truck drivers. To enable the use of the (dedicated truck parking) service, the logistics companies pay an *operating service fee* to the truck parking service provider.

Retailers/Shops (enriching partner)

Retailers/Shops are enriching partners which potentially lose their *flexibility in delivery*, but benefit from the *structured process by having scheduled delivery*. By providing *flexible delivery windows*, efficient delivery of freight in urban areas can be further improved, as it will place less pressures on the demand for suitable parking spots.

Global Service Provider

The global service provider is responsible for deploying mobility services in urban environments in the city / municipality. Part of this involves deploying the necessary RSUs and monitoring systems to generate parking and traffic information needed to operate mobility services. Accordingly, the value proposition of the global service provider is to generate or collect *parking information*. The global service provider does this via the co-production activity of *collecting parking availability information* through RSUs and dedicated monitoring cars that traverse the city to assess the real-time parking conditions. Through participation in the business model design, the global service provider incurs costs related to the deployment and maintenance of RSUs and monitoring cars. In addition, a service fee is paid to the truck parking service provider for offering a dedicated service for truck parking. In return, the global service provider is compensated by the municipality through a fixed *investment in the service*.

11.3. Operational scenario

The business model is enabled by an application for which the truck parking operator offers time and availability information about parking spots that are allocated for freight delivery, and *Truck Drivers* of logistics companies (or of specific associations) indicate their urban delivery information (required time and duration) through reservation. Such parking management schemes is necessary to bring a structure into the related process.

The key stakeholders include the *city / municipality* (that owns the parking spaces and is required to facilitate the service for traffic efficiency and security), *Retailers/Shops* (that require delivery of goods for their operation), and *Logistics Companies* (or Truck Associations) that offer the delivery service. *The Global Service Provider* ensures that the Truck Parking Provider can build upon real-time parking and traffic information. The City Municipality provides the parking space that are appropriate for freight delivery free to relevant parties, and pays the global service provider for collecting parking information, which subsequently compensates the truck parking provider for offering the dedicated service. In return, it benefits from the optimized use of parking space, and -more importantly from better traffic management leading to less traffic disruptions around these spots. The Parking Provider organizes the time availability of these parking spots, and operates the reservation system, and in turn benefits from the service fee it receives from the City Municipality. Although the Truck Drivers can be less flexible in the time-window for their delivery, they will spend less time (and fuel) for looking for appropriate parking spots and will benefit from securing a parking spot that can be more appropriate for loading/unloading. Trucks that stay longer than their reserved timeslot can be subject to increased parking rates or fines. As a remark, specific parking slots that are used for loading/unloading can be equipped with sensors that read licence plates to confirm the presence of the vehicles.

The operational scenario is depicted in the form of a choreography diagram in Figure 57. The choreography diagram includes an initial set-up scenario for the C-ITS solution (the flow at the top of the figure) and the operational scenario (the flow at the bottom of the figure).

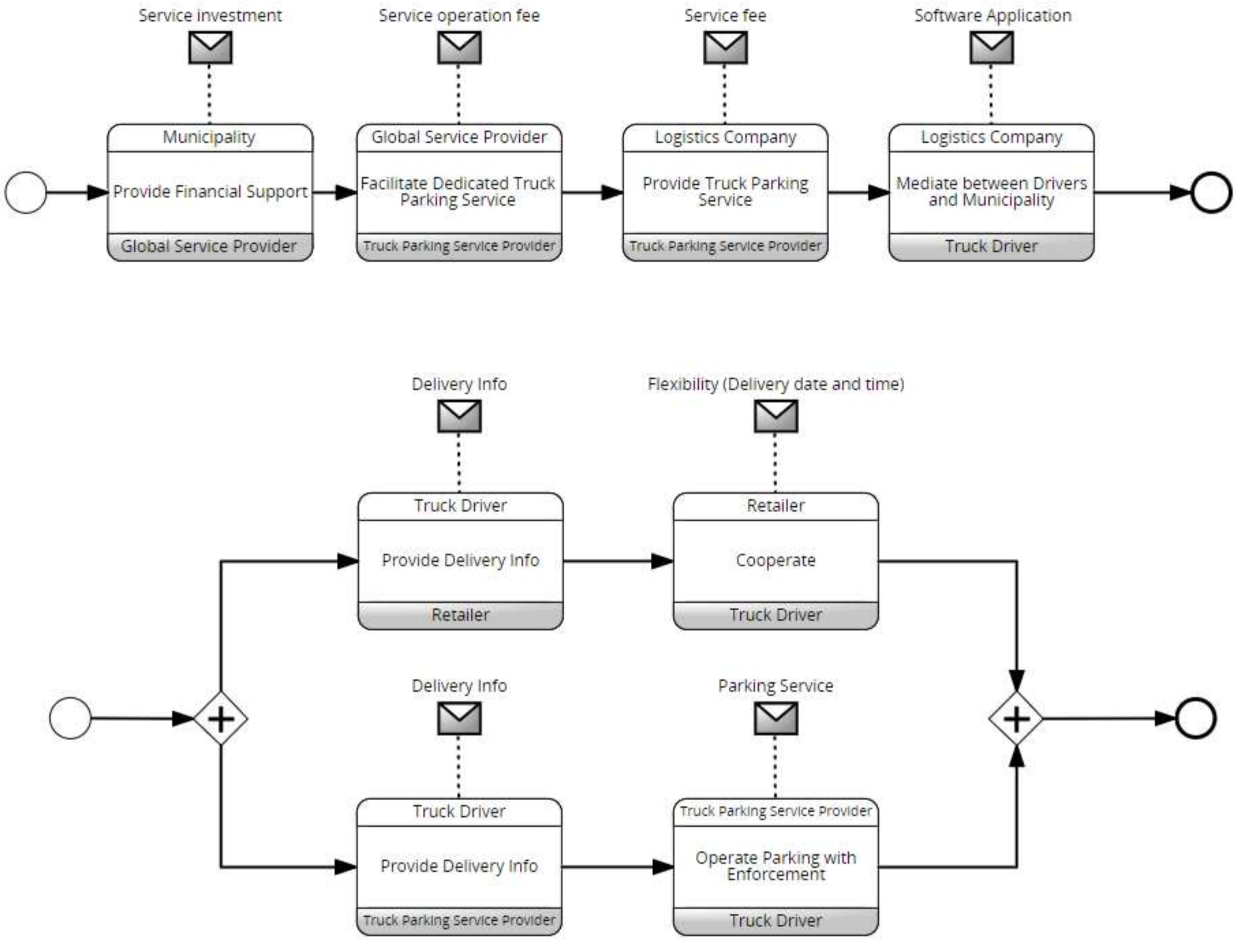


Figure 57: Choreography diagram for BM08- Efficient Freight Delivery in an Urban Areas

11.4. BM08 Business Case Analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM08 is depicted by means of the value capture diagram presented in Figure 58. As illustrated, BM08 consists of 6 actors, of which 4 (namely the truck parking service provider, logistics company, city / municipality and global service provider) generate financial or tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the truck driver and retailers generates intangible costs and benefits (e.g., largely related to perceptions and difficult to quantify or express in financial terms). For example, the retailer has costs related to offering additional flexibility, whereas it benefits from increased punctuality, both cost benefit items which have largely indirect financial implications (requiring significant assumptions to quantify in financial terms). Accordingly, we omit the perspective of the truck driver and retailers for the financial analysis of the business case for the business model design, and focus on the remaining 4 parties.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that city / municipality pays a *service investment* (e.g., a one-time payment) to the global service provider to implement and operate the service. In addition, the global service provider pays a *service fee* to the truck parking service provider to provide a dedicated truck parking service, leveraging the data collected by the global service provider. The logistics company also pays an *operating service fee* to the truck parking service provider to enable its truck drivers to use the service. As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that each of the actors also generate costs and benefits which are not based on exchange, and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions, traffic efficiency and fuel consumption).

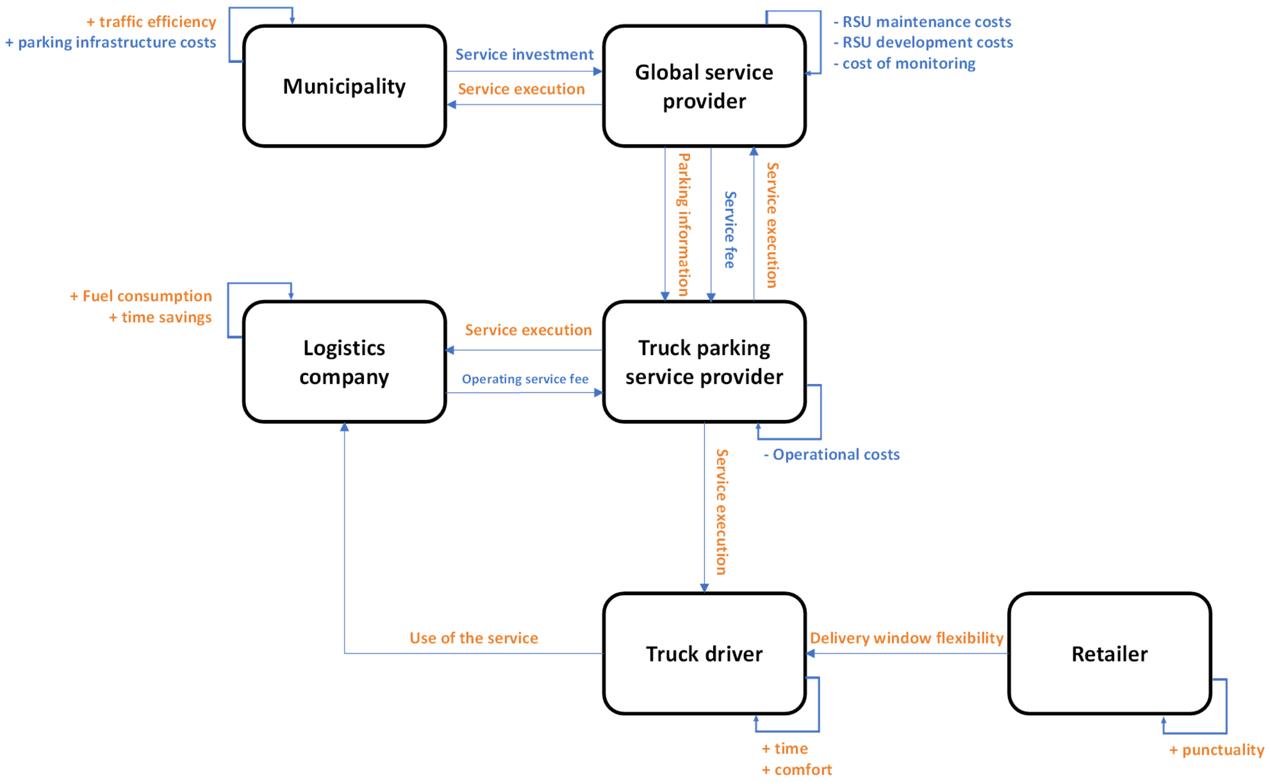


Figure 58: Value Capture Diagram BM08 – Efficient Delivery in Urban Area

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 9) have been used. These values are based on the deployments in *Bilbao, Spain deployment site* where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 9: Parameter settings used for BM08 business case analysis

Parameter description	Frequency	Value
Number of truck users	Per month	2000 users
Cost of application development	Fixed	5.000 euro
Cost of application maintenance	Per month	1.000 euro
Number of cars deployed to monitor parking availability	Fixed	50 euro
Cost per car deployed to monitor parking availability	Per month	200 euro
Number of parking spaces in Bilbao	Fixed	1.300 spaces[63]
Percentage of parking spaces equipped with RSUs	Fixed	30%
Number of RSUs required per parking space	Fixed	1[63]
Purchase cost per RSU	Fixed	1000 euro[63]
Maintenance cost per RSU	Per month	50 euro
Service investment (paid by city / municipality)	Fixed	4.000.000 euro[63]
Service fee (paid by global service provider)	Per month	5000 euro
Operating service fee (paid by logistics company)	Per month	2000 euro

[63] *Information obtained through Video-Conference – Bilbao [15-03-2021]*

Parameter description	Frequency	Value
Average time searching for a parking space	Per month	11 hours[64]
Value of an hour of time savings per truck driver	Fixed	18,40 euro[64]
Decrease in time needed to find a parking space as a result of service use	Fixed	1%
Number of stops needed to find a parking space	Fixed	5 stops
Average reduction in the amount of stops	Fixed	25%
Average consumption of fuel per stop	Fixed	0,70 liter[65]
Average fuel price	Fixed	1,31 euro[66]
Average driving speed in Bilbao	Fixed	30 km/h[63]
Average amount of road users in Bilbao	Fixed	200.000 users
Potential number of truck users in Bilbao	Fixed	20.000 users
Average number of trips per road user	Per month	10 trips
Average trip distance per road user	Fixed	10 kilometers
Value of a minute of time savings per road user	Fixed	0,28 euro[67]
Percentage average speed increase as a result of service use	Fixed	1%
Average cost of a parking space	Per week	12 euro[63]
Decreased need in parking spaces as a result of service use	Fixed	10%
Average fuel consumption	Fixed	0,073 L/km[68]
Emissions ton CO_2 per liter of fuel	Fixed	0,00264[69]
Monetary value of a ton CO_2	Fixed	€84,00[70]

11.4.1. Global Service Provider

The detailed tab for the global service provider is presented in Figure 59. One can see that the global service provider incurs costs related to the installation and maintenance of equipment (such as RSUs or specialized cars) to monitor the parking behavior. With regards to the cost of monitoring via cars (particularly for small streets that include private parking), 200 cars are expected to be used (which can freely move around the city), for which each car equates to a cost of €200 per month. Accordingly, the cost of monitoring via cars amounts to roughly €40.000 per month (€480.000 per year). The costs for equipment and maintenance of RSUs in contrast are dependent on the parking spaces that can build upon static monitoring. Considering that there are 1300 parking spaces in Bilbao, and that 30% of these parking spaces would require an RSU to monitor parking behavior, costs for equipment and maintenance of RSUs will amount to €650.000 (fixed) and €390.000 (per month) (assuming a purchase cost of €1000 per RSU and a maintenance cost of €50 per RSU).

		variable	fixed			
Cost of monitoring via car		€ 480.000,00				
				frequency	value	yearly value
Cost of monitoring parking availability via cars				per month	€ 40.000,00	€ 480.000,00
	Number of cars deployed			fixed	200	
	Cost per car			per month	€ 200,00	
		variable	fixed			
Equipment costs		€ -	€ 390.000,00			
				frequency	value	yearly value
Cost of equipment				fixed	€ 390.000,00	€ 390.000,00
	Number of parking spaces			fixed	1300	
	Percentage of parking spaces requiring RSUs			fixed	30%	
	Number of cameras per parking space			fixed	1	
	Cost of RSU			fixed	€ 1.000,00	
		variable	fixed			
Equipment maintenance cost		€ 234.000,00				
				frequency	value	yearly value
Cost of equipment				per month	€ 19.500,00	€ 234.000,00
	Number of parking spaces			fixed	1300	
	Percentage of parking spaces requiring RSUs			fixed	30%	
	Number of RSUs per parking space			fixed	1	
	Maintenance cost per RSU			per month	50	
		Variable	fixed			
Service fee (to truck parking prov.)		€ 60.000,00				
				frequency	value	yearly value
Service fee				per month	€ 5.000,00	€ 60.000,00

	Variable	fixed			
Investment for service operation		€ 4.000.000,00			
			frequency	value	yearly value
Investment in service (tender)			fixed	€ 4.000.000,00	€ 4.000.000,00

Figure 59: Breakdown of costs and benefits for global service provider

[64] https://www.fleetowner.com/fleet-management/article/21696064/truck-parking-and-traffic-congestion-intertwined
[65] https://carfromjapan.com/article/car-maintenance/how-much-gas-does-idling-use/
[66] https://www.anwb.nl/vakantie/reisvoorbereiding/euro-95-benzineprijzen-europa, Spain [29-04-2021]
[67] http://www.salaryexplorer.com/salary-survey.php?loc=2276&loctype=3, average salary of 2690 assuming 40-hour work week
[68] https://www.osti.gov/pages/servlets/purl/1339511#:~:text=The%20average%20fuel%20consumption%20is,regulation%20(EU%2C%202009), an average consumption of 7.32 litres per 100 km
[69] https://ecoscore.be/en/info/ecoscore/co2
[70] https://www.en-former.com/en/metric-ton-co2-cost/

To enable more dedicated service provisioning to truck drivers, the global service provider collaborates with the truck parking service provider to do so. In return for the efforts of the truck parking service provider, the global service providers pays a service fee (in this scenario set to €60.000 per year).

For facilitating and operating the service, the global service provider receives a fixed compensation of the city. In this scenario, this service investment is set to €4.000.000.

11.4.2. Truck Parking Service Provider

The detailed tab for the truck parking service provider is presented in Figure 60. One can see that the costs for the truck parking service provider pertain to development and maintenance of the service application, to be used by end-users. In particular for this scenario, the development and maintenance costs for the service application are set to €5.000 fixed and €1000 per month respectively. In return, the truck parking service provider receives a service fee from the global service provider (as explained set to €60.000 per year) to offer the service to a dedicated customer base (in this scenario, truck drivers). In addition to this, the truck parking provider also receives an operating service fee from the logistic provider in return for providing the service to its truck drivers. In this business scenario, this operating service fee is set to €2.000 per month (€24.000 per year).

	variable	fixed	frequency	value	yearly value
Platform costs	€ 12.000,00	€ 5.000,00			
Application development cost			fixed	€ 5.000,00	€ 5.000,00
Application maintenance cost			per month	€ 1.000,00	€ 12.000,00

	Variable	fixed	frequency	value	yearly value
Service fee (to truck parking prov.)	€ 60.000,00				
Service fee			per month	€ 5.000,00	€ 60.000,00

	Variable	fixed	frequency	value	yearly value
Operating service fee	€ 24.000,00				
Operating service fee (to truck service prov.)			per month	€ 2.000,00	€ 24.000,00

Figure 60: Breakdown of costs and benefits for truck parking service provider

11.4.3. City

The detailed tab for the city is presented in Figure 61. As explained for the global service provider, the city pays the global service provider to implement and operate the service (in this case also involving the efforts of a dedicated truck parking service provider). Accordingly, the city incurs costs related to the initial investments in the service (€4.000.000). As a result of service use, the city can capture benefits in terms of improved traffic efficiency and decreased investments or expenditures with regards to building new parking spaces. With regards to traffic efficiency, we extrapolate the impact of service use on traffic efficiency based on how many road users currently use the service versus the amount of road users present in Bilbao. Assuming on average a 1% increase in speed can be achieved if all trucks would use the service, and assuming that the average speed in Bilbao is 30km/h and that the average number of trips per road user is 10, each trip covering a distance of 10km, the effect on traffic efficiency would be valued at €60.000 per year.

	Variable	fixed	frequency	value	yearly value
Investment for service operation		€ 4.000.000,00			
Investment in service (tender)			fixed	€ 4.000.000,00	€ 4.000.000,00

		Variable	fixed	frequency	value	yearly value
Value of improved traffic efficiency		€ 60.000,00				
Value of improved traffic efficiency				per month	€ 5.000,00	€ 60.000,00
	Percentage average speed increase (km/h)			fixed	1%	
	Average speed in Bilbao (km/h)			fixed	30	
	Users of the service			per month	2000	
	Potential truck users in Bilbao			per month	20000	
	Number of road users in Bilbao			per month	200000	
	Average number of trips per road user			per month	10	
	Average trip distance in Bilbao (km)			fixed	10	
	Value of minutes saved per road user			fixed	€ 0,25	

		Variable	fixed	frequency	value	yearly value
Saved expenditures on building new parking spaces		€ 81.120,00				
Saved expenditures on building new parking spaces				per week	€ 1.560,00	€ 81.120,00
	Average parking space cost			per week	€ 12,00	
	Decreased need in parking spaces			fixed	10%	
	Amount of parking spaces			fixed	1300	

Figure 61: Breakdown of costs and benefits for city

With regards to saved expenditures on parking spaces, assuming use of the service decreases the need for new parking spaces by 10%, and considering that on average a parking space entails maintenance / development costs of €12 per month for the municipality, the saved expenditures on parking spaces would amount to €81.120.

11.4.4. Logistics Company

The detailed tab for the logistics company is illustrated in Figure 62. As indicated for the truck parking service provider, the logistics company pays an operating service fee of €2.000 per month to the truck parking service provider, enabling its truck drivers to use the service and thus improve the effectiveness / efficiency of a searching for a suitable parking spot. As a result, the logistics company can benefit from time savings for its truck drivers, as well as a decrease in fuel consumption as truck drivers are able to find a suitable parking spot more quickly and efficiently. With regards to time savings, on average trucks spend up to 11 hours per month to find / park at a suitable parking spot, for which an hour of time 'lost' would equate to €18,40[71]. If this time is reduced by 1% by the urban parking availability, and considering 2000 truck users actively using the service, the logistics company(ies) would be able to benefit from savings up to €48.576. In addition, the use of urban parking availability may also prevent truck drivers from having to stop and turn unnecessarily. If we assume that on average a truck driver requires 3 stops to find a suitable parking spot in the inner city, and assuming that use of the service would reduce this amount by 25%, logistics company(ies) would further benefit from savings in fuel consumption amounting €17.213 per year.

	Variable	fixed	frequency	value	yearly value
Operating service fee	€ 24.000,00				
Operating service fee (to truck service prov.)			per month	€ 2.000,00	€ 24.000,00

		Variable	fixed	frequency	value	yearly value
Time savings due to service		€ 48.576,00				
Time savings search for parking space				per month	€ 4.048,00	€ 48.576,00
	Number of truck users			per month	2000	
	Average time searching for parking space (hours)			per month	11	
	Value of hour time save			fixed	€ 18,40	
	Decrease in time searched as a result of service			fixed	1%	

		Variable	fixed	frequency	value	yearly value
Decrease in fuel consumption		€ 17.213,40				
Decrease in fuel consumption				per month	€ 1.434,45	€ 17.213,40
	Number of truck users			per month	2000	
	Number of stops / turns to find a parking spot			fixed	3	
	Average reduction in the amount of stops			fixed	25,00%	
	Average consumption of fuel per stop (litre)			fixed	0,73	
	Average fuel price			fixed	€ 1,31	

Figure 62: Breakdown of costs and benefits for logistics company

11.4.5. Results of Business Case Analysis

Based on the selected parameter settings, the business case results as presented in Figure 63 are obtained. One can see that based on the selected parameters, the truck parking provider, city, and logistics company generate a positive financial outcome, whereas the global service provider generates a negative financial outcome of €774.000. Examining the case for the global service provider, this makes sense as the benefits for the global service provider pertain to a one-time, fixed investment of 4.000.000 paid by the city. For the current scenario, this implies that the global service provider will generate a negative return on investment after roughly 5 years. At that moment in time however, the mobility and ITS landscape may have changed significantly, which likely will influence the variable costs incurred per year – accordingly, at that moment, new strategic decisions with regards to the business model design can be taken to address these costs. In contrast, one can observe that the city is required to make a fixed investment of 4.000.000 to support the deployment of the service, but in turn benefits from a decreased needed to build new parking spaces and benefits from increased traffic optimization for its inhabitants (amounting €141.120). Although viable in the long-term, this does mean that it will take significant time (roughly 25 years) for the city to break-even (solely considering traffic efficiency benefits). If other benefits are considered (such as the effects on road safety or the decrease in pollution), this payback period can be further reduced. In the case the costs for the global service provider can be reduced, or if other services can be considered as well (for example the widespread deployment of urban parking availability, not just catered to trucks), additional benefits can be generated.

For the truck parking provider and the logistics company, the results demonstrate that the benefits outweigh the costs. The service fee and operating service fee received from the global service provider and logistics company respective compensate the development and maintenance of the software application to provide the service. Moreover, even though the truck parking provider is required to invest in the development of the service application (amounting a fixed €5.000 investment), the operation profit is sufficiently high to compensate for these expenses in the first year. For the logistics company, the time savings and decrease in

[71] *https://www.fleetowner.com/fleet-management/article/21696064/truck-parking-and-traffic-congestion-intertwined*

fuel consumption generated through use of the service are sufficient to compensate for the operating service fee paid to the truck parking provider.

Global service provider

Costs	Value	Frequency	Benefits	Value	Frequency
Cost of cars for monitoring	€ 480.000,00	per year	Investment for service	€ 4.000.000,00	fixed
Equipment for monitoring cost	€ 390.000,00	fixed			
Equipment for monitoring main	€ 234.000,00	per year			
Service fee	€ 60.000,00	per year			
Total	€ 774.000,00		**Total**	€ -	
Yearly balance	€ -774.000,00				
Fixed investment	€ -3.610.000,00				

Logistics Company

Costs	Value	Frequency	Benefits	Value	Frequency
Operating service fee	€ 24.000,00	per year	Time savings due to parking	€ 48.576,00	per year
			Decrease in fuel consumption	€ 18.900,00	per year
Total	€ 24.000,00		**Total**	€ 67.476,00	
Yearly balance	€ 43.476,00				
Fixed investment	€ -				

Truck Parking Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Application development cost	€ 5.000,00	fixed	Service fee	€ 60.000,00	per year
Application maintenance cost	€ 12.000,00	per year	Operating service fee	€ 24.000,00	per year
Total	€ 12.000,00		**Total**	€ 84.000,00	
Yearly balance	€ 72.000,00				
Fixed investment	€ 5.000,00				

City

Costs	Value	Frequency	Benefits	Value	Frequency
Investment for service	€ 4.000.000,00	fixed	Value of increased traffic optimization	€ 60.000,00	per year
			Saved expenditure parking spaces	€ 81.120,00	per year
Total	€ -		**Total**	€ 141.120,00	
Yearly balance	€ 141.120,00				
Fixed investment	€ 4.000.000,00				

Figure 63: Financial Dashboard BM08

12. BM09 - Faster and Safer Travel of Emergency Vehicles

12.1. Description

Green priority service can be combined with emergency vehicle warning to reduce the response times of the emergency vehicles, such as ambulances, fire trucks, and police cars (see Section 19.7 and 19.4, respectively, for more information about these services). The combination of the two services can be implemented as follows. The green priority request including the identification information of the emergency vehicle can be published via on-board C-ITS applications in the vehicle. Consequently, traffic light controllers can pick up this information and determine in what way they can and will respond the request. The same information can also be picked up by road-side units (RSUs) and/or other vehicles and cooperatively communicated to the traffic on the route of the emergency vehicle. This combination not only allows emergency vehicles to travel faster and safer but also allows other vehicles to react faster and in a safe manner.

The business model aims to provide fast and safe cruising of emergency vehicles in urban areas with the support of specific technology services (namely green priority and emergency vehicle warning). The green priority service aims to change the traffic signal status in the path of an emergency (or high priority) vehicle to support halting conflicting traffic and allowing the vehicle right-of-way, thereby enhancing traffic safety. The appropriate level of the green priority can depend on vehicle characteristics, such as type (e.g., emergency vehicle) or status (e.g., public transport vehicle on-time or behind schedule). This service can be combined with the emergency vehicle warning to reduce the response times of the emergency vehicles.

The value proposition of the business model is green priority for public transport to make it more desirable by increasing the timeliness of the public transport services. By making use of this increased priority, especially for the behind-the-schedule vehicles, public transport operators provide increased punctuality for their public transportation services. As a result, the cities will benefit from increased use of public transportation, decreased pollution, and an improved image due to increased punctuality of the public transportation.

The blueprint business model is given in Figure 64.

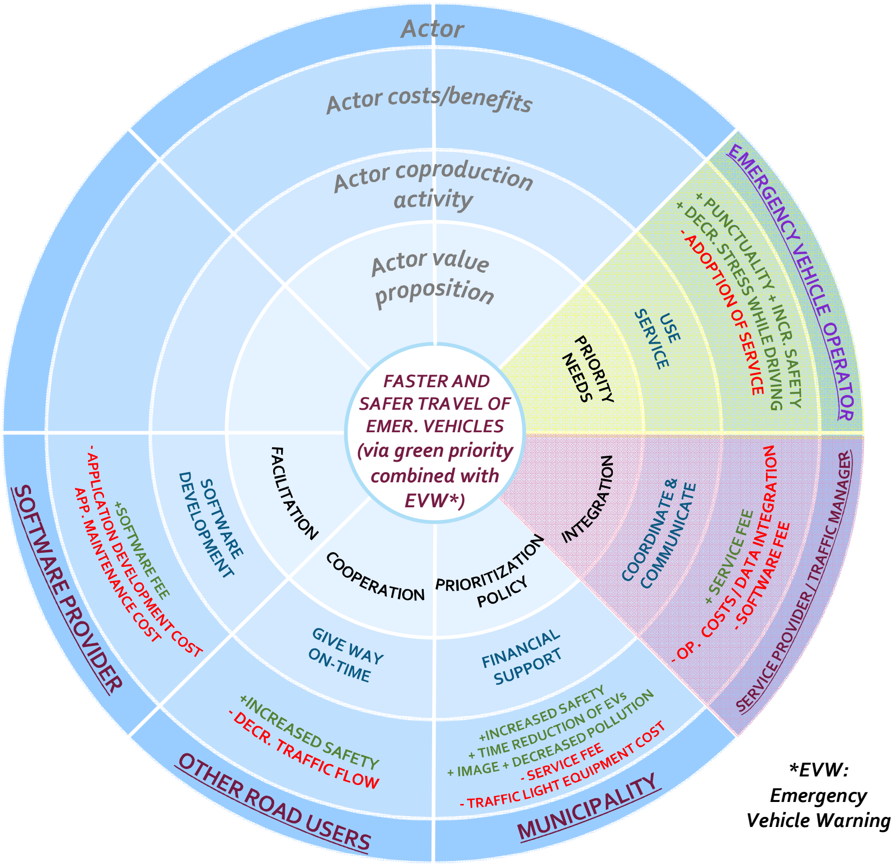


Figure 64: Business model radar for BM09 - Faster and Safer Travel of Emergency Vehicles

12.2. Involved Actors

Emergency vehicle operator (customer)

The Emergency vehicle operator receives increased priority for its vehicles and by making use of this increased priority, quicker response times for the cases of emergency. The emergency vehicle warning accompanying the emergency vehicles downstream their route, guide other vehicle drivers and further increase the response times. As the response times reduce (increasing *punctuality*), the overall safety of the citizens of the city increases with the operating efficiency of the emergency vehicle operator. Reasonably, *adoption costs* are incurred however to effectively use the service, the emergency vehicle operator benefits from *lessened driver stress* in return.

Service provider / traffic manager (orchestrator)

To provide green priority and emergency vehicle warning, the green priority request including the identification information of the emergency vehicle can be published via on-board C-ITS applications in the vehicle. Consequently, traffic light controllers (or service providers in private-public partnerships) can pick up this information and determine in what way they can and will respond to the request. The same information can also be picked up by road-side units (RSUs) and/or other vehicles and cooperatively communicated to the traffic on the route of the emergency vehicle. The value proposition for the service provider / traffic manager is *integration* of these data stream, enabling the service to work as intended for emergency vehicle operators. The service provider / traffic manager benefits from a *service fee* paid by the municipality for facilitating and operating the service. To support the technical infrastructure needed for the service, a *software fee* is paid to the software provider, whereas *operational costs* are incurred with regards to data integration.

Municipality (core partner)

To compensate for the costs incurred in offering the service, the municipality can act as a sponsoring party. The municipality as such *subsidizes* the service to facilitate its deployment, paying a *service fee* to the traffic manager / service provider to stimulate service operation. As a result, the city municipality (City of Vigo in this case) benefits from *increased citizen and road safety, increased timeliness of emergency vehicles* (resulting during the response period of the emergency cases) and *decreased pollution* (as through use of the service emergency vehicles are likely to avoid unnecessary stops or moments of deceleration, retaining a more balanced driving speed). As mentioned, the municipality supports the service by paying a *service fee* to the service provider. In addition, the municipality is charged with outfitting the traffic lights such that the service can be operated (incurring *traffic light equipment costs* in doing so).

Software provider (core partner)

The software provider is responsible for development and maintenance the software required to support the service operations (enabling the service to interact with traffic lights and to ensure that data can be collected). With the data streams provided by this infrastructure, the traffic manager can provide green priority and disseminate emergency vehicle warning. In return for the *operational costs* related to its co-production activities (e.g., the *development and maintenance of the infrastructure* or software application), the technical service provider benefits from the *software fee* paid by the service provider to use this software platform.

Other vehicle drivers (enriching partner)

The value propositions offered by the other traffic users is *cooperation* in the cases of emergency. This basically involves giving-way in a timely manner after receiving the emergency vehicle warning. Therefore, part of their value proposition is also *their absence*; as such, traffic congestion on the downstream of the emergency vehicle is reduced. The other vehicle drivers benefit from *a safer driving experience* as hazardous scenarios are avoided. However, they can suffer from *a decrease in the traffic flow* caused by giving way to the emergency vehicles.

12.3. Operational scenario

In the operational scenario, the traffic manager offers increased priority for the emergency vehicles operated by the emergency vehicle operator. By making use of this increased priority, emergency vehicle operator provides quicker response times for the cases of emergency. To compensate the increased operating costs, the emergency vehicle operator benefits from lessened driver stress in return. The technology infrastructure required for the services is installed and maintained by the technical service provider. In return for the operational costs related to its co-production activities, the technical service provider benefits from the subsidy support provided by the city municipality. Similarly, the traffic manager will benefit from potential market advantage and better market position in return for the operational costs resulting from the prioritization of the traffic lights. Furthermore, the city municipality benefits from increased citizen safety, decreased number of accidents resulting during the response period of the emergency cases, and an improved image of the city as the safety of the citizens is increased, which may validate offering financial support (in terms of subsidies) to participate in the business model.

Other traffic users are given timely warnings regarding the emergency vehicle and expected to cooperate so that the potential traffic congestion on the downstream of the emergency vehicle is reduced. They benefit from a safer driving experience as hazardous scenarios are decreased. Furthermore, the city/municipality benefits from increased citizen safety, decreased number of accidents resulting during the response period of the emergency cases, and an improved image, which may justify offering financial support to participate in the business model.

The operational scenario is depicted in the form of a choreography diagram in Figure 65. The choreography diagram includes an initial set-up scenario for the C-ITS solution (the flow at the top of the figure) and the operational scenario (the flow at the bottom of the figure). *(Appendix-C describes how a choreography diagram can be interpreted.)*

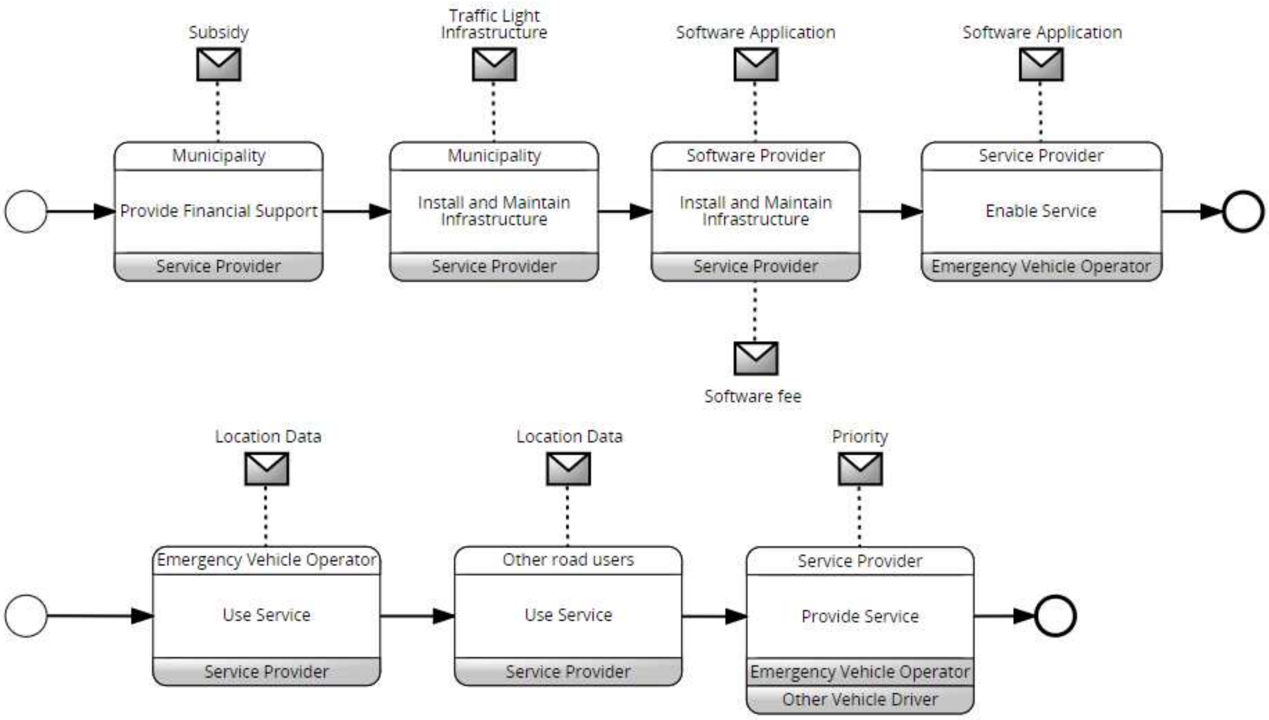


Figure 65: Choreography diagram for BM09 - Faster and Safer Travel of Emergency Vehicles

12.4. BM09 - Business Case Analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM09 is depicted by means of the value capture diagram presented in Figure 66. As illustrated, BM09 consists of 5 actors, of which 3 (namely the service provider / traffic manager, municipality and software provider) generate or exchange financial or tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the emergency vehicle operator and other road users generate largely intangible costs and benefits (e.g., largely related to perceptions and difficult to quantify or express in financial terms) and are not directly involved for the financial exchanges occurring in the model. Accordingly, we omit the perspective of the emergency vehicle operators and other road users for the financial analysis of the business case for the business model design, and focus on the remaining 3 parties. Again, do note that even though the emergency vehicle operators and other road users are not included for the financial business case analysis, as stakeholders they serve a valuable role for the viability and feasibility of the design.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that municipality pays a *service fee* to the service provider to operate and offer the service to emergency vehicle operators. On the other hand, the service provider pays a *software fee* to the software provider to support the development and maintenance of the software / application needed to operate the service. As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that each of the actors also generate costs and benefits which are not based on exchange, and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as emissions and increased safety). Here, we exclude the financial quantification of the value of emergency vehicles arriving timelier at destinations (listed as a benefit for the municipality), as this largely results in indirect financial effects (requiring significant assumptions to be quantified, reducing the accuracy of the resulting outcome).

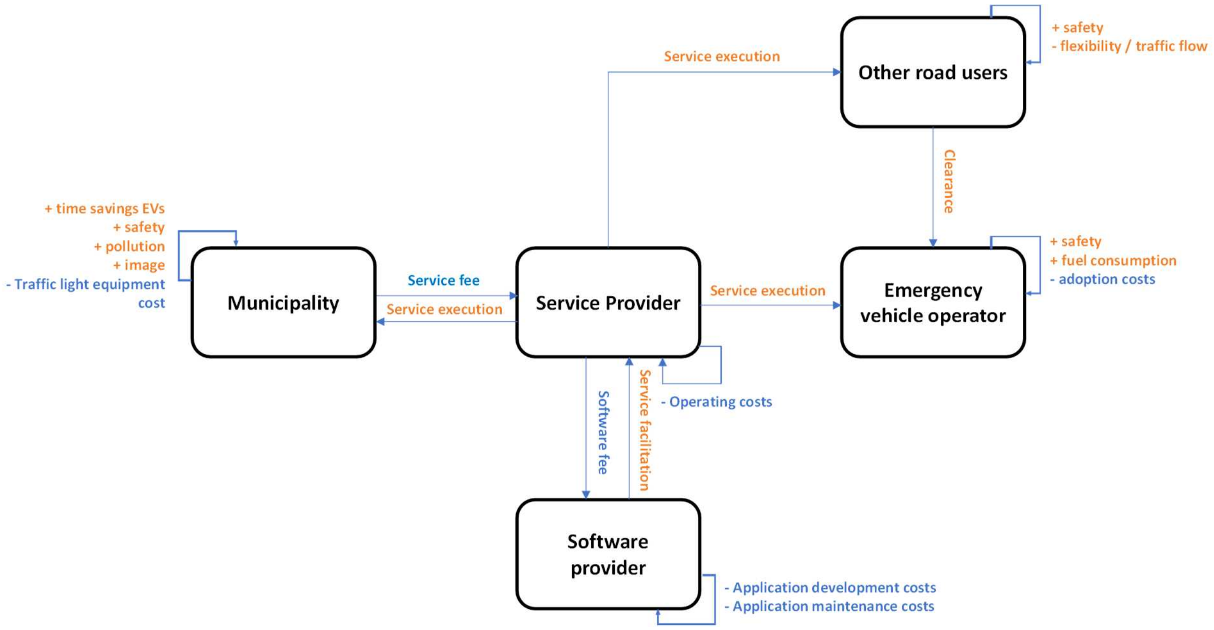


Figure 66: Value Capture Diagram BM09 – Faster and Safer Travel of Emergency Vehicles

We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 10) have been used. These values are based on the deployments in the *Vigo, Spain* deployment site where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 10: Parameter settings used for BM09 business case analysis

Parameter description	Frequency	Value
Number of current emergency vehicle users	Per month	100 users
Software fee	Per month	1000 euro
Service fee	Per month	2000 euro
Cost of service operation	Per month	500 euro
Cost of software development	Fixed	5000 euro
Cost of software maintenance	Per month	100 euro
Service fee (paid by city)	Per month	1000 euro
Number of intersections	Fixed	136[72]
Number of RSUs	Per intersection	1 RSU[72]
Development / installation cost of a RSU	Fixed	500 euro
Maintenance cost of a RSU	Per month	100 euro
Number of fatal road accidents (Vigo)	Per year	3 fatal accidents[73]
Number of severe road accidents (Vigo)	Per year	38 severe accidents[73]
Number of light road accidents (Vigo)	Per year	979 light accidents[73]
Cost of fatal road accident	Fixed	2.800.000 euro[74]
Cost of serious road accident	Fixed	300.000 euro[74]
Cost of light road accident	Fixed	1.000 euro[74]
Potential number of emergency vehicle users	Per year	1000 users
Potential decrease in road accidents as a result of service use	Fixed	10%
Decrease in fuel consumption as a result of not stopping	Fixed	0,7 liter[75]

[72] *Information obtained through Video-Conference – Vigo [23-03-2021]*
[73] *Extrapolated from https://www.statista.com/statistics/1019526/number-of-traffic-accidents-spain/ (102.000 accidents), assuming that Vigo (1% of the inhabitants of Spain) accounts for 1% of the accidents. Then, using the weights calculated in https://www.dgt.es/Galerias/seguridad-vial/estadisticas-e-indicadores/publicaciones/principales-cifras-siniestralidad/2017-2799_Summary_Main_figures_on_road_safety_data_Spain_2016_ACCESIBLE.pdf, assess how many fatal, severe and light accidents can be considered.*
[74] *https://www.swov.nl/en/facts-figures/factsheet/road-crash-costs*
[75] *https://carfromjapan.com/article/car-maintenance/how-much-gas-does-idling-use/*

Parameter description	Frequency	Value
Percentage amount of stops emergency vehicles	Fixed	30%
Reduction in amount of stops as a result of service	Fixed	30%
Average emissions of tCO_2	Per liter	0,00264 tCO_2[76]
Monetary value of 1 tCO_2	Fixed	84,00 euro[77]
Frequency of an emergency vehicle passing the service trajectory	Per month	50 times

12.4.1. Service Provider

The detailed tab for the service provider is presented in Figure 67. The costs for the service provider in this scenario relate to operating the service as well as the compensation paid to the software provider for using a dedicated service platform. Here, the software provider is paid a monthly €1.000, enabling the service provider in return to use the software platform to operate the service. With regards to the service operation itself, a €500 monthly cost is assumed to do so. With regards to the benefits for the service provider, a service fee is received from the municipality (as compensation for operating the service). In this scenario, this service fee is set to €2000 per month (€24.000 per year), enough to compensate for the costs incurred as a result of the business model.

		Variable	fixed	frequency	value	yearly value
Software fee		€ 12.000,00				
				frequency	value	yearly value
Software fee				per month	€ 1.000,00	€ 12.000,00
	Software fee paid to the software provider			per month	1000	

		Variable	fixed	frequency	value	yearly value
Cost of service operation		€ 6.000,00				
				frequency	value	yearly value
	Cost of service operation			per month	€ 500,00	€ 6.000,00

		Variable	fixed	frequency	value	yearly value
Service fee		€ 24.000,00				
				frequency	value	yearly value
Service fee				per month	€ 2.000,00	€ 24.000,00
	Service fee paid by the municipality			per month	2000	

Figure 67: Breakdown of costs and benefits for service provider

12.4.2. Municipality

The detailed tab for the municipality is illustrated in Figure 68. One can see that the costs for the municipality are related to the service fee that is paid to the service provider to operate the service (set to €2.000 per month) and are related to the cost of purchase, installation, and maintenance of the required RSU equipment to facilitate the service operation. In Vigo, 136 intersections are considered, for which each intersection is outfitted with 1 RSU. Assuming that the costs purchase and deployment of a single RSUs is €500 (fixed), whereas the maintenance costs for a single RSU equate to €100 per month, the total costs for the municipality regarding the deployment and maintenance of RSUs are €68.000 (fixed) and €163.200 (per month) respectively.

		Variable	fixed	frequency	value	yearly value
Service fee		€ 24.000,00				
				frequency	value	yearly value
Service fee				per month	€ 2.000,00	€ 24.000,00
	Service fee paid by the municipality			per month	2000	

		variable	fixed	frequency	value	yearly value
Cost of RSU equipment		€ -	€ 68.000,00			
				frequency	value	yearly value
Cost of RSU equipment				fixed	€ 68.000,00	€ 68.000,00
	Number of intersections			fixed	136	
	Number of RSUs per intersection			fixed	1	
	Cost per RSU			fixed	€ 500,00	

		variable	fixed	frequency	value	yearly value
Cost of RSU maintenance		€ 163.200,00				
				frequency	value	yearly value
Cost of RSU equipment				per month	€ 13.600,00	€ 163.200,00
	Number of intersections			fixed	136	
	Number of RSUs per intersection			fixed	1	
	monthly maintenance cost RSU			per month	€ 100,00	

		Variable	fixed	frequency	value	yearly value
Value of road safety		€ 110.350,17				
				frequency	value	yearly value
Value of increased safety				per year	€ 110.350,17	€ 110.350,17
	Number of fatal accidents			per year	3	
	Cost of fatal accident			fixed	€ 2.800.000,00	
	Number of serevere accidents			per year	38	
	Cost of severe accident			fixed	€ 300.000,00	
	Number of light accidents			per year	979	
	Cost of light accident			fixed	€ 1.000,00	
	Current number of EV users			per year	100	
	Potential number of EV users			per year	1000	
	Potential decrease in accidents as a result of service			fixed	5%	
	Number of road accidents				102000	

		Variable	fixed	frequency	value	yearly value
Value of decreased pollution		€ 114.002,38				
				frequency	value	yearly value
Value of decreased pollution				per month	€ 9.500,20	€ 114.002,38
	Decrease in fuel consumption as a result of not stopping			fixed	0,7	
	Number of intersections			fixed	136	
	Average amount of stops for intersections			fixed	30%	
	Reduction in amount of stops			fixed	30%	
	Average emissions of tCO2 per litre			fixed	0,002640	
	Monetary value of 1 tCO2			fixed	€ 84,00	
	Current number of EV users			per month	100	
	Frequency of EV user passing service trajectory			per month	50	

Figure 68: Breakdown of costs and benefits for municipality

[76] https://ecoscore.be/en/info/ecoscore/co2
[77] https://www.en-former.com/en/metric-ton-co2-cost/

As use of the service enables emergency vehicle drivers to travel more safely and efficiently to their required destinations, both the frequency of road accidents (involving emergency vehicles) as well as pollution (as a result of decreased emissions) can be reduced, which are considered benefits for the municipality. Extrapolating from the number of current EV users against the potential number of EV users and the average expected decrease in accidents as a result of this, we can calculate the effect of service use on the number of accidents that can be avoided. These accidents can be further categorized in terms of their severity (e.g., light, severe and fatal) and can be expressed in financial terms based on their expected impact. Considering that Vigo represents roughly 1% of the Spanish population and that on average 102.000 road accidents per year occur in Spain[78], and further considering that fatal, severe, and light accidents account for 0,34%, 3,73% and 95,93% respectively[78], we can quantify the value of avoided road accidents, which amounts to €110.350,17 per year (assuming the corresponding 'value' of fatal, severe and light accidents to be €2.800.000, €300.000 and €1.000 respectively)[74].

With regards to decreased pollution, green priority enables emergency vehicle drivers to avoid having to slow down or stop at intersections (as priority is given). In turn, this should decrease overall fuel consumption for emergency vehicles, meaning less pollution is generated. Assuming that on average for the 136 equipped intersections, emergency vehicles normally are required to stop / slow down at 30% of the intersections, and that through use of the service 30% of these stops can be avoided, we can calculate the resulting decrease in fuel consumption and its related effect on pollution. Assuming that on average emergency vehicle drivers pass the supported trajectory 50 times per month and considering average emissions of 0,002640 tCO_2/L[76] and a value of 1tCO_2 of €84,00[77], monetary benefits can be achieved up to €114.002,38 per year.

12.4.3. Software Provider

The detailed tab for the software provider is presented in Figure 69. The costs for the software provider are associated with the development and maintenance of the software platform, which is used by the service provider to operate the service. Here, a development cost of €5000 (fixed) and a monthly maintenance cost of €100 are assumed for the software platform development and maintenance. With regards to the benefits, the software provider benefits from the software fee paid by the service provider (as a compensation to use the software platform). As explained, this fee is set to €1.000, which is large enough to compensate for the platform expenses made.

	variable	fixed			
Cost of software platform	€ -	€ 5.000,00			
			frequency	value	yearly value
cost of software platform development			fixed	€ 5.000,00	€ 5.000,00
Development cost			fixed	€ 5.000,00	
	variable	fixed			
Software platform maintenan	€ 1.200,00				
			frequency	value	yearly value
Software platform maintenance			per montl	€ 100,00	€ 1.200,00
Monthly maintenance cost			per montl	€ 100,00	

	Variable	fixed			
Software fee	€ 12.000,00				
			frequency	value	yearly value
Software fee			per month	€ 1.000,00	€ 12.000,00
Software fee paid to the software provider			per month	1000	

Figure 69: Breakdown of costs and benefits for software provider

12.4.4. Results of Business Case Analysis

Based on the selected parameter settings, the business case results as presented in Figure 70 are obtained. One can see that for the current parameter settings, all actors generate a positive financial outcome. Even though the municipality incurs upfront costs with regards to outfitting the traffic lights for the service to be used, it generates significant benefits in terms of road safety and pollution, enabling the municipality to break even in 1 year. The same holds for the software provider, which although upfront costs are incurred related to the development of the software infrastructure, captures benefits (in terms of the *software fee* received from the service provider) that more than outweigh these initial costs. Note that the viability of the business model design depends strongly on the adoption of the service. In the current scenario, 100 users of the service are expected. In case this adoption is not reached (for example, dropping below 75 users), the municipality fails to generate a long-term viable scenario. In addition, for the current scenario, a reduction in traffic accidents of 10% is considered. If based on the current user base, only a 5% reduction can be realized, the municipality fails to break even. Therefore, for this business model design, it is key to stimulate adoption of the service operation (and to also consider the role of other road users as an enriching stakeholder for the viability of the business model).

[78] *https://www.statista.com/statistics/1019526/number-of-traffic-accidents-spain/*

Service Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Software fee	€ 12.000,00	per year	Service fee	€ 24.000,00	per year
Cost of service operation	€ 6.000,00	per year			
Total	€ 18.000,00		**Total**	€ 24.000,00	
Yearly balance	€ 6.000,00				
Fixed investment	€ -				

Municipality

Costs	Value	Frequency	Benefits	Value	Frequency
Service fee	€ 24.000,00	per year	Increased road safety	€ 110.350,17	per year
Cost of RSU equipment	€ 68.000,00	fixed	Decreased pollution	€ 114.002,38	per year
Cost of RSU maintenanc	€ 163.200,00	per year			
Total	€ 187.200,00		**Total**	€ 224.352,55	
Yearly balance	€ 37.152,55				
Fixed investment	€ 68.000,00				

Software Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Software application dev	€ 5.000,00	fixed	Software fee	€ 12.000,00	per year
Software application mai	€ 1.200,00	per year			
Total	€ 1.200,00		**Total**	€ 12.000,00	
Yearly balance	€ 10.800,00				
Fixed investment	€ 5.000,00				

Figure 70: Financial Dashboard BM09

13. BM10- Comfortable Walking in the City-Centre

13.1. Description

Cities are obliged to facilitate and enhance the mobility of vulnerable road users (VRUs) – in particular of elderly or handicapped/physically challenged pedestrians. Traffic light prioritization can be used for increasing safety and comfort for such designated VRUs, enhancing their experience in participating in urban life (see Section 19.9 for more information about this service). To foster this, a service provider offers priority crossing for special citizens via a smartphone application, which can be activated through software codes. These codes are provided by governmental organizations, municipalities, or other non-profit organizations to those citizens with the objective to help increase their quality of life.

To operate the service, the data concerning the location and travel direction of the pedestrian is collected through the smartphone application. The application runs in the background; as such, no interference of the person is needed. Moreover, traffic lights are equipped with necessary technology, allowing the application to interact with these systems. Once the person (carrying a smartphone with active application) approaches the traffic light, two scenarios can occur. In case of a red light, increased priority is given to the person by activating the green light quickly and allowing him/her to continue with reduced waiting time. In case of a green light, the duration is extended to support the flow.

The blueprint business model is given in Figure 71.

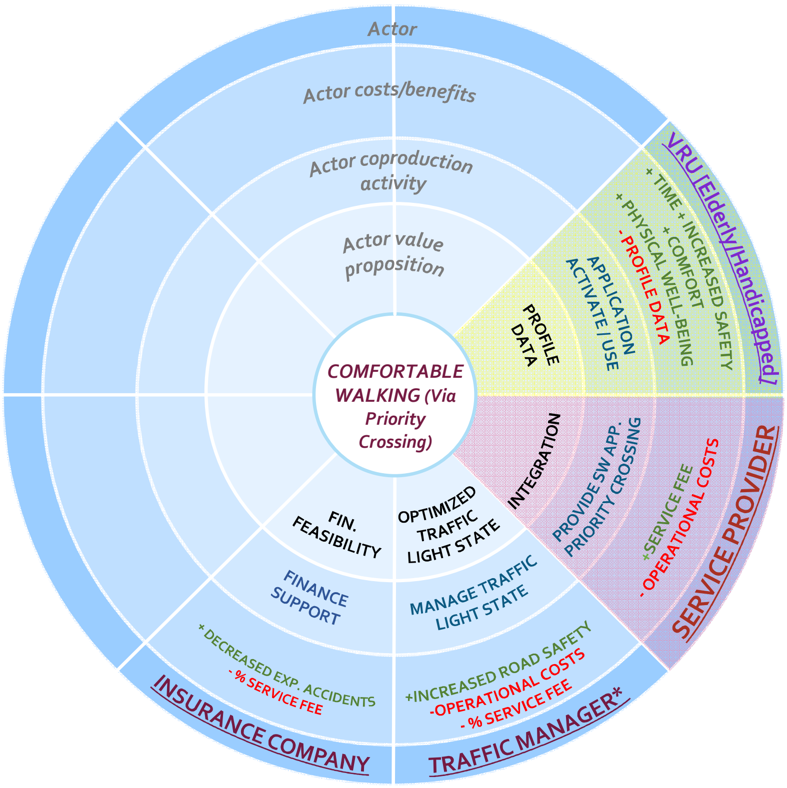


Figure 71: Business model radar for BM10- Comfortable Walking in City-Centre

13.2. Involved Actors

VRU (customer)

The VRU (elderly/handicapped) uses the code to activate the application, which runs in the background and interacts with traffic lights (and associated systems at intersections). The application tracks the location and direction of the VRU and integrates this data with traffic light state information to provide traffic light prioritisation to cyclists. This service can be customized or adapted based on the user's characteristics or profile (i.e., handicapped, or elderly user). Therefore, the value proposition of the VRU is to provide (profile) data, which is generated through the coproduction activity of activating and using the software application. The VRU benefits from shorter travelling and increased comfort, as stops at traffic lights are decreased or even avoided. As a cost, the VRU must provide profile and/or location data, particularly if the service should be customized to the user's needs.

Service provider (orchestrator)

The service provider provides traffic light prioritisation to its users. The service depends on integrating floating cyclist data with traffic light state data to provide priority to approaching VRUs at a specific traffic light. This data is consequently forwarded to the traffic manager. Therefore, the value proposition of the service provider is to *integrate* both sources of data in order to provide the service to the user. As coproduction activity, the service provider provides the software application to operate the service and integrate both streams of data. The service provider benefits from *service fees* paid to activate and using the service, whereas *operational costs* are incurred to manage and maintain the software application and service.

Traffic manager (core partner)

The traffic manager is responsible managing the traffic lights and providing optimized traffic light states for cyclists using the service application. Based on the integrated data received from the service provider, the traffic manager warrants either priority to additional crossing time at traffic lights (i.e., either faster time to green or extended green). Therefore, the value proposition of the traffic manager is to offer *optimized traffic light states*, which is offered through the coproduction activity of *managing traffic light states*. The traffic manager benefits from a more *VRU friendly image*, as the business model stimulates comfortable commuting. Moreover, as priority is given to VRUs, a *less stressful and safer experience to VRUs* can be offered, whereas accidents can be avoided. In turn, this should further benefit the traffic *image*. As a cost, the traffic manger compensates part of the *service fee* paid to the service provider for operating the service. In addition, operational costs are incurred to manage the traffic lights to enable the service provisioning.

Insurance company (core partner)

Through use of the service by VRUs, the number of road accidents (involving VRUs) can be decreased, which in turn is beneficial for insurance companies, as less insurance compensation with regards to road accidents must be paid. Given this benefit, the insurance company may be stimulated to participate in the business model design and to contribute to its financial feasibility. Therefore, the value proposition of the insurance company is supporting the *financial feasibility* of the business model design. The insurance company does so through the coproduction activity of *providing financial support,* which incorporates compensating part of the service fee paid to the service provider (such that VRUs are able to use the service for free). The insurance company will benefit from *decreased compensation paid because of the decreased accidents*.

13.3. Operational scenario

In the operational scenario, the VRU uses the code to activate the application, which runs in the background and interacts with traffic lights (and associated systems) at intersections. As such, no interference of the VRU is needed. Once the VRU -with this application running in his/her smart phone, approaches to the traffic light, two scenarios can occur. In case of a red light, increased priority is given to the VRU by activating the green light quickly and allowing cyclist to continue with reduced waiting time. In case of a green light, the duration is extended to support the flow.

The traffic manager offers increased priority for the VRUs approaching to specific traffic lights or intersections. With this increased priority, the VRU benefits from shorter travelling and increased comfort, as stops at traffic lights are decreased or even avoided. To compensate the increased operating costs, the traffic manager benefits from a more VRU friendly image in return. The application required for the service is installed and maintained by the service provider. In return for the operational costs related to its co-production activities, the service provider benefits from the service provided by the non-profit organization.

The operational scenario is depicted in the form of a choreography diagram in Figure 72. The choreography diagram includes an initial set-up scenario for the C-ITS solution (the flow at the top of the figure) and the operational scenario (the flow at the bottom of the figure).

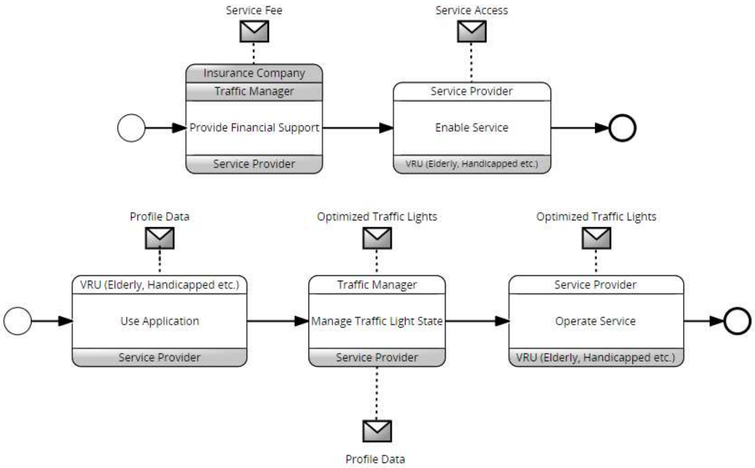


Figure 72: Choreography diagram for BM10- Comfortable Walking in City-Centre

13.4. BM10 - Business Case Analysis

The exchange of costs and benefits, as well as the remaining self-generated for BM10 is depicted by means of the value capture diagram presented in Figure 73. As illustrated, BM10 consists of 4 actors, of which 3 (namely the service provider, traffic manager and employer) generate financial or tangible (e.g., can be reasonably quantified or expressed in financial terms) costs and benefits, whereas the VRUs generate largely intangible benefits (and do not partake in the exchange of financial value). Accordingly, we omit the perspective of the VRU for the financial analysis of the business case for the business model design, and focus on the remaining 3 parties.

Zooming in on the transactions made between actors (which provide room for negotiation and thus exploration of the financial viability of the model) we observe that the insurance company as well as the traffic manager pay a percentage of a *service fee* to the service provider to stimulate the service use and operation, in turn benefiting the insurance company and traffic manager through a reduction of accidents. No alternative incentive schemes, particularly directed to the end user / customer are included (other than the service being free of charge). As the concretization of these parameters depends on negotiation and input from the involved stakeholders (and thus are more flexible in nature rather than built upon estimates), these parameters are used to conduct what-if analysis to explore different business case scenarios. In addition, we observe that most of the actors also generate costs and benefits which are not based on exchange, and are either already in financial terms (such as operational costs or investments) or can be expressed in such terms (such as road safety).

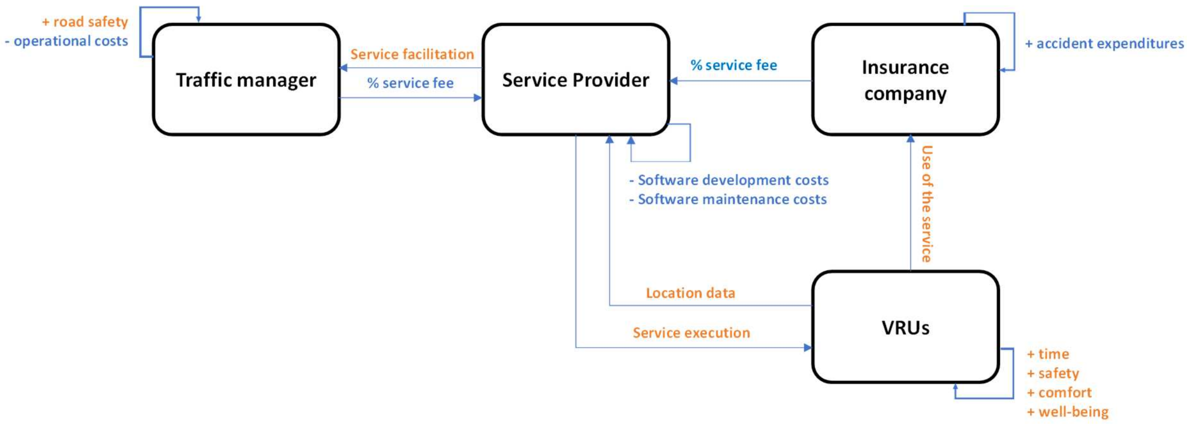


Figure 73: Value Capture Diagram BM10 - Comfortable Walking

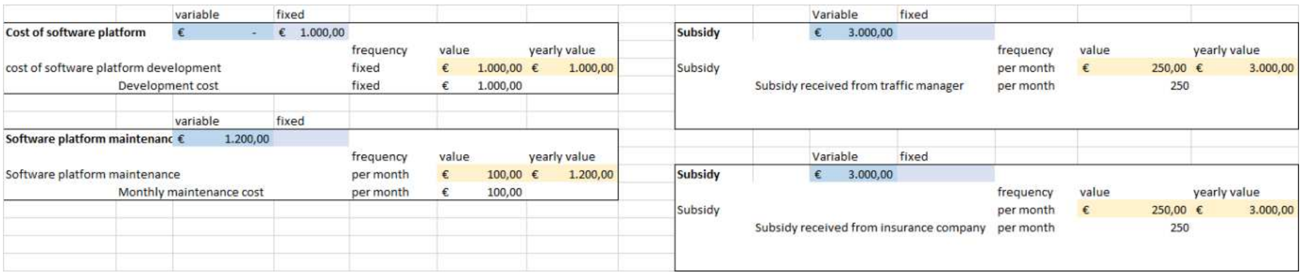
We leverage financial spreadsheets (using Excel) to assess the balance of costs and benefits. To generate these results, the following parameter settings (Table 11) have been used. These values are based on the deployments in *the Eindhoven, Netherlands* (North Brabant site) where applicable. Per actor, we will now discuss how their respective (financial) costs and benefits have been calculated. Subsequently, we illustrate the outcomes of the business case analysis and discuss potential scenarios to further improve business model viability. Note that the results detail per actor both the fixed, up-front costs or benefits as well as the *yearly* balance of costs or benefits that can be expected.

Table 11: Parameter settings used for BM10 business case analysis

Parameter description	Frequency	Value
Number of VRU users	Per month	200 users
Cost of software platform development	Fixed	1000 euro
Cost of software platform maintenance	Per month	100 euro
Percentage of service fee paid by insurance company	Fixed	50%
Percentage of service fee paid by traffic manager / city	Fixed	50%
Service fee	Per month	500 euro
Number of intersections supported through service	Fixed	20[79]
Number of RSUs per intersection	Fixed	2[79]
Development / purchase cost per RSU	Fixed	1000 euro
Maintenance cost per RSU	Fixed	50 euro
Number of VRU fatalities as a result of road accidents	Per year	70 fatalities[80]
Potential amount of VRU users available	Per month	20000 users
Potential reduction in road accidents as a result of service use	Fixed	5%
Average cost of a road fatality	Fixed	2800000 euro[81]
Percentage of costs road fatality compensated by insurance	Fixed	50%

13.4.1. Service Provider

The detailed tab for the service provider is illustrated in Figure 74. One can see that the costs for the service provider are related to the development and maintenance of the software / service application, such that end-users can actively make use of the service. In this scenario, these costs are set to €1.000 (fixed development) and €100 (monthly maintenance) respectively. In terms of benefits, the service provider receives a service fee/ subsidization, compensated through the joint efforts of the traffic manager/municipality and insurance company(ies). Here, it is assumed that both the traffic manager and insurance company pay a monthly €250 fee.



		variable	fixed			
Cost of software platform		€ -	€ 1.000,00			
				frequency	value	yearly value
cost of software platform development				fixed	€ 1.000,00	€ 1.000,00
	Development cost			fixed	€ 1.000,00	
		variable	fixed			
Software platform maintenanc		€ 1.200,00				
				frequency	value	yearly value
Software platform maintenance				per month	€ 100,00	€ 1.200,00
	Monthly maintenance cost			per month	€ 100,00	

		Variable	fixed			
Subsidy		€ 3.000,00				
				frequency	value	yearly value
Subsidy				per month	€ 250,00	€ 3.000,00
	Subsidy received from traffic manager			per month	250	
		Variable	fixed			
Subsidy		€ 3.000,00				
				frequency	value	yearly value
Subsidy				per month	€ 250,00	€ 3.000,00
	Subsidy received from insurance company			per month	250	

Figure 74: Breakdown of costs and benefits for service provider

13.4.2. Traffic Manager

The detailed tab for the service provider is illustrated in Figure 75. The costs for the traffic manager are associated with the deployment and maintenance of RSU infrastructure to facilitate the service operation, as well as the service fee paid to the service provider to operate the service. For the case in Eindhoven, 20 intersections are considered, for which each intersection is outfitted by 2 RSUs to facilitate service operation. Assuming that the development / purchase and deployment cost of an RSU is equal to €1.000 (fixed), and the maintenance cost for a single RSU is equal to €50,00 per month, the total costs amassed equate to €40.000 (one-time) and €24.000 (per year) respectively. As explained, in addition, the traffic manager pays a fee to the service provider to operate the service (in this scenario set to €250 per month). Note that the percentage of compensation can be altered, depending on agreements made with regards to how the compensation is paid through the joint efforts of the traffic manager and insurance companies.

Use of the service should enable VRUs to benefit from extended green light periods or reduced time to green light waiting periods, enabling such VRUs to more comfortably and safely cross intersections. In turn, this

[79] *Information obtained through Video-Conference – Eindhoven [20-03-2021]*
[80] *Extrapolated for North-Brabant (assuming age category 60+) from https://www.cbs.nl/en-gb/news/2020/16/more-traffic-deaths-among-people-in-their-twenties-and-thirties*
[81] *https://www.swov.nl/en/facts-figures/factsheet/road-crash-costs*

should decrease the number of accidents involving VRUs, which is considered as the primary benefit for the city in this business model design. Extrapolating the road fatalities involving VRUs (specifically elderly) for North Brabant[82], on average 70 road accidents involving VRUs occur. Consequently, based on the ratio between current amount of VRU users versus the total potential number of users, as well as the expected reduction in accidents as a result of service use, the monetary value of a reduction in traffic accidents can be calculated. Assuming an average cost of a fatal accident of €2.800.000, these benefits would amount to €98.000.

		Variable	fixed	frequency	value	yearly value
Service fee		€ 3.000,00				
				frequency	value	yearly value
Service fee				per month	€ 250,00	€ 3.000,00
	Total service fee			per month	500	
	Percentage paid by traffic manager			fixed	50%	
		variable	fixed			
Cost of traffic light equipment		€ -	€ 40.000,00			
				frequency	value	yearly value
Cost of traffic light equipment				fixed	€ 40.000,00	€ 40.000,00
	Number of intersections			fixed	20	
	Number of RSUs per intersection			fixed	2	
	Development / purchase cost per RSUs			fixed	€ 1.000,00	
		variable	fixed			
Cost of RSU maintenance		€ 24.000,00				
				frequency	value	yearly value
Cost of RSU equipment				per month	€ 2.000,00	€ 24.000,00
	Number of intersections			fixed	20	
	Number of RSUs per intersection			fixed	2	
	monthly maintenance cost RSU			per month	€ 50,00	

		Variable	fixed	frequency	value	yearly value
Improved well-being of VRUs		€ 98.000,00				
				frequency	value	yearly value
Improved well-being of VRUs				per year	€ 98.000,00	€ 98.000,00
	Number of VRU fatalities by road accidents			per year	70	
	Number of service users			fixed	200	
	Potential amount of users			fixed	20000	
	Potential reduction in road accidents			fixed	5%	
	Average cost of road fatality			fixed	€ 2.800.000,00	

Figure 75: Breakdown of costs and benefits for the traffic manager

13.4.3. Insurance Company

The detailed tab for the service provider is illustrated in Figure 76. One can see that the insurance company pays 50% of the service fee for the service provider, in this scenario amounting to €250 per month. Analogously to the traffic manager, the benefits for the insurance company(ies) relate to the reduction in accidents as a result of service use (which in turn decreases the payouts made with regards to insurance contracts and policies). Assuming that 50% of the avoided road accident costs as a result of service use are compensated by the insurance company, this implies that the monetary value for the insurance company equates to €49.000.

		Variable	fixed	frequency	value	yearly value
Subsidy		€ 3.000,00				
				frequency	value	yearly value
Subsidy				per month	€ 250,00	€ 3.000,00
	Total subsidy paid			per month	500	
	Percentage paid by insurance company			fixed	50%	

		Variable	fixed	frequency	value	yearly value
Improved well-being of VRUs		€ 49.000,00				
				frequency	value	yearly value
Improved well-being of VRUs				per year	€ 49.000,00	€ 49.000,00
	Number of VRU fatalities by road accidents			per year	70	
	Number of service users			fixed	200	
	Potential amount of users				20000	
	Potential reduction in road accidents			fixed	5%	
	Average cost of road fatality			fixed	€ 2.800.000,00	
	Percentage of costs road fatality compensated by insuranc			fixed	50%	

Figure 76: Breakdown of costs and benefits for the insurance company

13.4.4. Results of Business Case Analysis

Based on the selected parameter settings, the business case results as presented in Figure 77 are obtained. One can see that for the current parameter settings, all actors included for the business case analysis obtain a positive financial outcome. Even though the traffic manager has significant investments related to the outfitting of traffic lights such that these can interact with the service (amounting €40.000), the benefits generated through use of the service (e.g., road accidents involving VRUs can be reduced) significantly outweigh both the variable costs incurred as well as its initial investments. Note furthermore that the RSUs deployed may also serve other business cases, reducing these initial costs even further. A similar case holds for the insurance company, for which under the assumption that 50% of the expenses for road accidents are compensated by the insurance company, the insurer can significantly offset the percentage of service fee paid to the service provider. For the service provider, the received service fee (a combined €6000) is sufficient to compensate the costs incurred for software development and maintenance. Given the strong case for the insurer and traffic manager, the service fee can even be increased further in case additional costs arise for the service provider.

[82] *https://www.cbs.nl/en-gb/news/2020/16/more-traffic-deaths-among-people-in-their-twenties-and-thirties*

Service Provider

Costs	Value	Frequency	Benefits	Value	Frequency
Software development	€ 1.000,00	fixed	Service fee received from traffic manager	€ 3.000,00	per year
Software maintenance	€ 1.200,00	per year	Service fee received from insurer	€ 3.000,00	per year
Total	€ 1.200,00		**Total**	€ 6.000,00	
Yearly balance	€ 4.800,00				
Fixed investment	€ 1.000,00				

Traffic Manager

Costs	Value	Frequency	Benefits	Value	Frequency
Service fee	€ 3.000,00	per year	Increased road safety	€ 98.000,00	per year
Cost of traffic light outf	€ 40.000,00	fixed			
Cost of traffic light mair	€ 24.000,00	per year			
Total	€ 27.000,00		**Total**	€ 98.000,00	
Yearly balance	€ 71.000,00				
Fixed investment	€ 40.000,00				

Insurance Company

Costs	Value	Frequency	Benefits	Value	Frequency
Service fee	€ 3.000,00	per year	Decreased expenditure road accidents	€ 49.000,00	per year
Total	€ 3.000,00		**Total**	€ 49.000,00	
Yearly balance	€ 46.000,00				
Fixed investment	€ -				

Figure 77: Financial Dashboard BM10

14. Survey for the Evaluation of the Business Model Blueprints

In this section, we present the results of a survey study (available in *Appendix D* and at: https://forms.gle/2gEtQg4PxcxotJJv6) that has been conducted for the evaluation of the business model blueprints presented in Section 3. The purpose of the survey study was to gain an understanding of the views of the end-users and key stakeholders in the mobility domain – and particularly in C-MobILE deployment sites - on the business model blueprints that are envisioned to address a number of current and future transport and mobility challenges in urban areas.

Accordingly, the survey questionnaire included two main parts:

Part-1: Questions for determining the stakeholder profile and cities of the respondents.

Part-2: Seven questions on evaluating the set of 10 business model blueprints.

In total, 48 respondents participated in the survey. There were five major stakeholder profiles among which respondents were expected to choose based on the profile they would like to represent. These were:

1. Governmental/Public Organisations: Local authorities, public road operators/traffic authorities, public transport operators, public emergency services, and others as such
2. Citizens: Travellers including drivers, pedestrians, cyclists, and physically challenged/disabled road users, mobility service users (e.g., public transport user), and other citizens of such
3. Businesses/Operators: Transport (& logistics) operators, mobility service providers (including vehicle rental/sharing, parking, maps, navigation & data, mobile network operators), technology providers (OEM, software, etc.), private emergency services and operators, and other businesses as such
4. Other Service Providers: Insurance companies, retailers, media and leisure/entertainment services, engineers/contractors, and other providers as such
5. Policy Advisors/Communities/*Innovation Agencies/*Research Agencies: Public-private partnerships, NGOs, associations (cyclists, motorist, automobile clubs, forums, etc.), trade bodies, licensing and legislators, incubators, and research institutes & universities

The distribution among these 48 respondents with respect to these 5 profiles is presented in Figure 78. As can be seen, 35% of the respondents participated in the survey as *citizens*, while the rest is balanced between other categories, with the exception of other service providers.

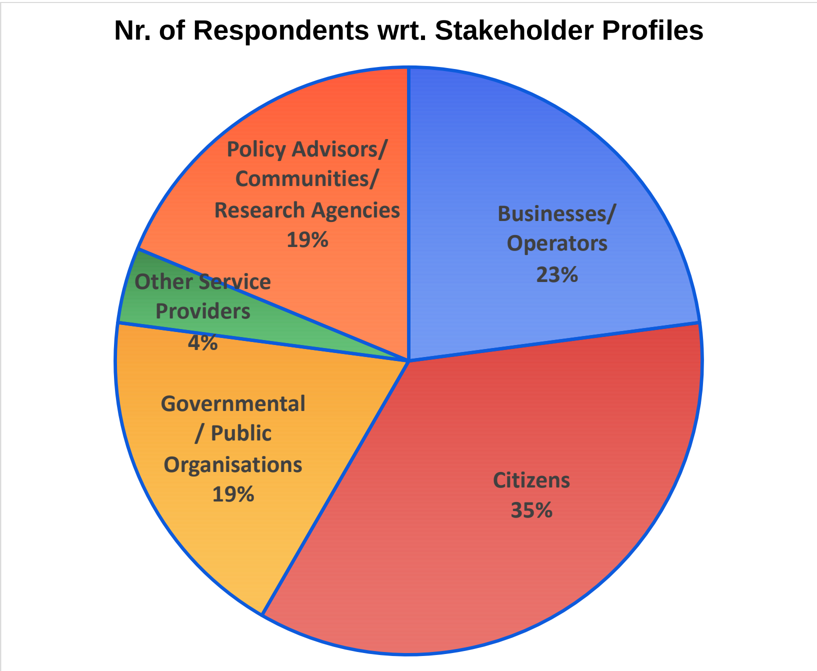


Figure 78: Number of Respondents with respect to Stakeholder Profiles

Furthermore, the distribution of 48 respondents according to their cities is presented in Figure 79.

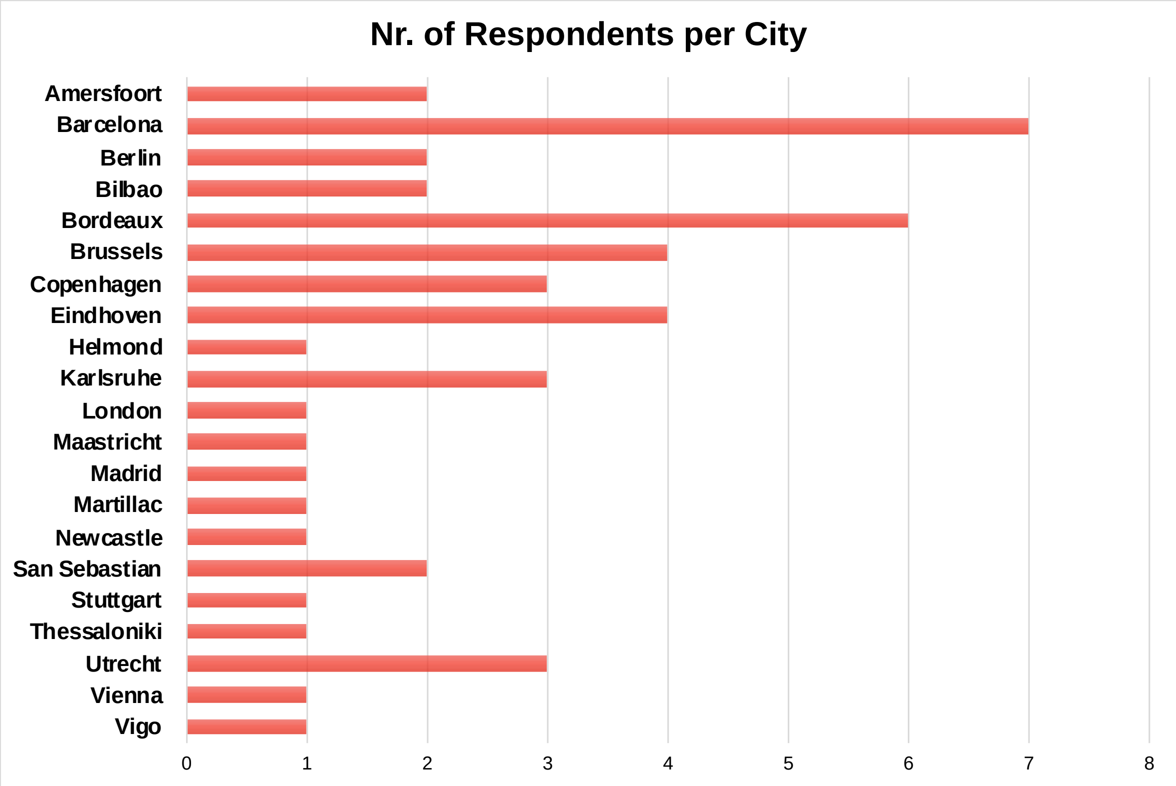


Figure 79: Number of respondents per European City

For the second part of the survey, respondents provided a total of 63 unique evaluations on 10 business model blueprints. The distribution of 63 responses according to the business model blueprint is presented in Figure 80.

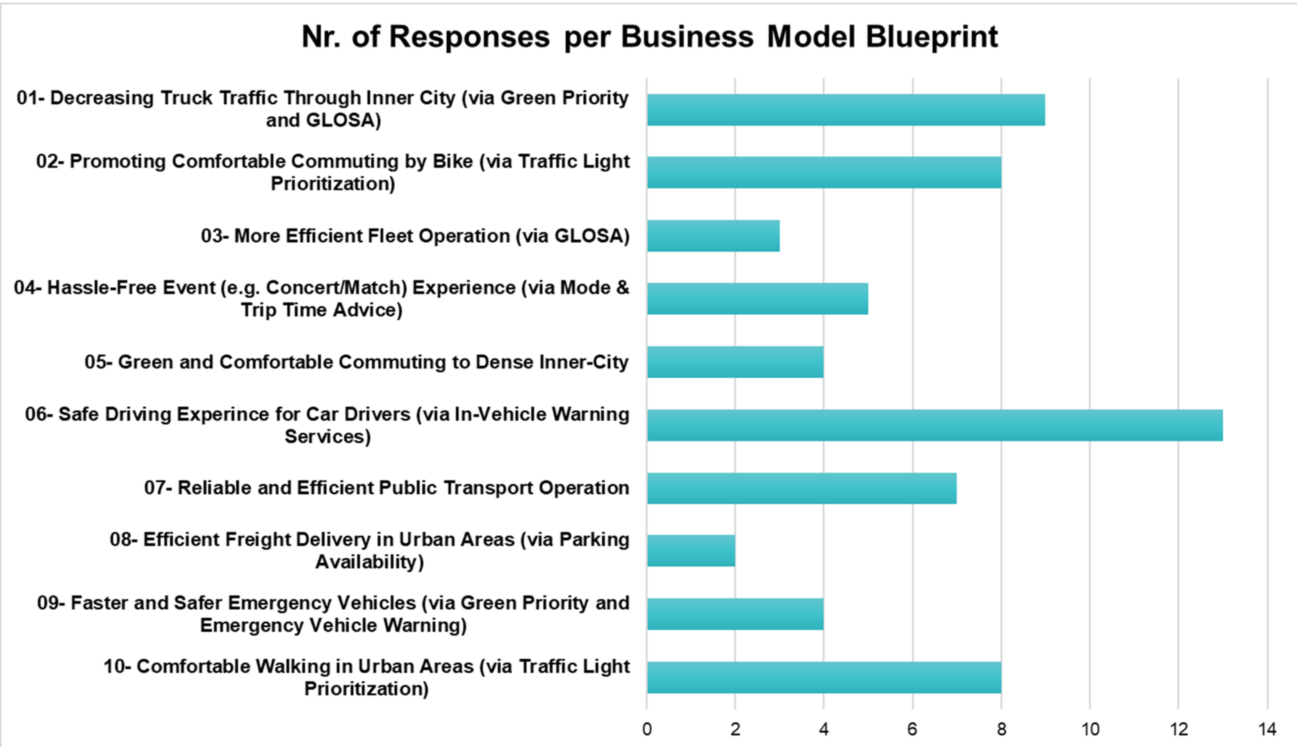


Figure 80: Number of respondents per business model blueprint

In the second part of the questionnaire, we asked participants to qualitatively evaluate service solutions depicted in the blueprints from different perspectives. In responding to these questions, we asked C-MobILE deployment sites to *reflect* on their views based on the *actual implementations* of these service solutions in their cities.

Participants have evaluated the blueprints through *seven* questions; *six* in the form of closed questions (Likert-scale, very high to very low), and *one* open question. Each closed question represents a unique business model evaluation perspective. Table 12 presents the six evaluation perspectives alongside with their descriptions. These evaluation questions have been based on prior academic work focusing on the qualitative evaluation of service-dominant business models [25], [26].

Table 12: Business model evaluation perspectives and questions

Evaluation Perspective	Questions *(Likert-scale: Very Low - Low - Medium - High - Very High)*
1. Solution Fitness	Q1: To what extent would the proposed service solution (depicted in the business model blueprint) help in addressing the mobility challenge?
2. Completeness of the Solution	Q2: To what extent is the list of stakeholders needed for the proposed service solution complete?
3. Presence of Barriers	Q3: To what extent are legal or technological barriers present towards implementation of the service solution (depicted in the business model blueprint)?
4. Establishment of Trust	Q4: To what extent does trust or mutual understanding exist or can be established between actors in the service solution (depicted in the business model blueprint)?
5. Balance in Costs and Benefits	Q5: To what extent can the costs and benefits per stakeholder in the service solution realistically be balanced?
6. Certainty in Costs and Benefits	Q6: To what extent are costs and benefits listed per stakeholder subject to uncertainty?

We asked respondents to indicate -for each service- the extent to which the service's influences these impact areas. Respondents provided their answers on a 5-point Likert Scale with items ranging from Very Low to Very High. The results for the first six questions are presented in Figure 81.

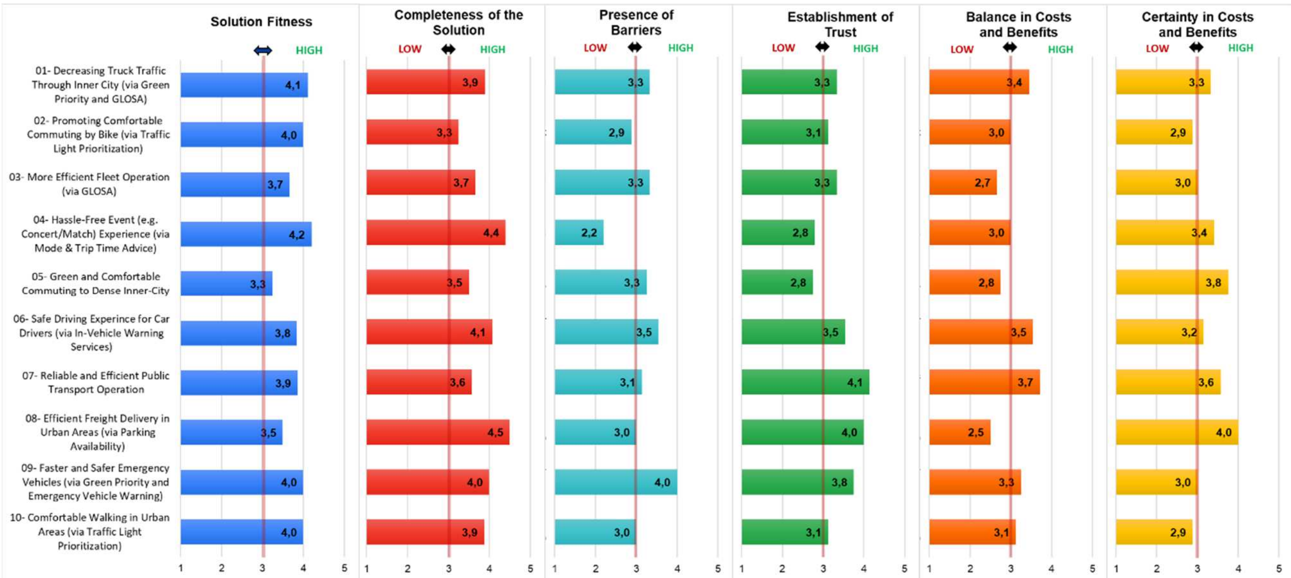


Figure 81: Responses regarding the evaluation perspectives (*Answers for Q3-Presence of Barriers reversed*))

Overall, no *major* risk, barrier or issues have been pointed out by the participants for any of the business model blueprints. All business model blueprints are considered to have the potential to effectively address the targeted mobility challenges (*solution fitness*). As similar conclusion can be reached with respect to the completeness of the list of stakeholders needed for the proposed solution (*completeness of the solution*); i.e., all blueprints are considered to incorporate necessary stakeholders.

In general, participants considered that a number of service solutions depicted in the blueprints (e.g., *BM1-Safer & More Secure Fleet Operation, BM04- Hassle-free Event Experience*) are subject to legal or technological barriers towards their implementations (*presence of barriers*). For instance, the absence of intelligence traffic lights in some cities and their different use (e.g., statically/dynamically controlled) pose difficulties in the effective deployment of the GLOSA service.

Establishment of trust among stakeholders considered also to be a potential hinderance, particularly for service solutions that involve relatively higher number of stakeholders and are more multifaceted in nature (*establishment of trust*). For instance, both *BM04- Hassle-free Event Experience* and *BM05- Green and Comfortable Commuting to Dense City* service solutions incorporate relatively complex scenarios and involve many stakeholders of different nature that must tightly cooperate and to be closely orchestrated by a focal organization.

Participants also considered few solutions to suffer from difficulties in realistically balancing the costs and benefits per stakeholder in the service solution. For instance, *BM08- Efficient Freight Delivery in an Urban Areas* is considered to have the highest risk with respect to this perspective. The actual deployment of this service solution in one of our local sites (Bilbao) also provided evidence for this risk. Similarly, *BM03- More Efficient Fleet Operation* that involve GLOSA service are considered to potentially suffer from finding an ideal context where its revenues outweigh its deployment and operational costs.

When it comes to the certainty in the cost and benefit items in the blueprints (*certainty in costs and benefits*), many of the participants considered that the costs and benefits listed per stakeholder are subject to reasonable level of certainty. This is with the exception of the blueprints *BM08- Efficient Freight Delivery in an Urban Areas*, and *BM05- Green and Comfortable Commuting to Dense City*, which are recognized as to have high certainty in the associated costs and benefits.

Participants have also asked to answer the open question, where they have indicated their remarks on other factors related to blueprints that they have evaluated. For a number of blueprints, (e.g., *BM04- Hassle Free Event Experience)*, the responses to the open question gathered important feedback – particularly regarding the barriers, establishment of trust and balance in costs and benefits. The feedback obtained on these perspectives have been incorporated into the tasks of finalizing the blueprints. Consequently, some changes and suggestions are processed and included in the final version of the business model blueprints.

15. Reference Blueprint for the Design of Business Models in the Mobility Domain

In this section, we present a reference blueprint for the design of business models in the smart mobility domain. In the following sections, we first provide the motivation behind such a blueprint and how it was designed. As a next step, we provide the reference blueprint model alongside with the actors and roles that it incorporates.

15.1. Motivation

Smart mobility initiatives concern the development of connected ecosystems to stimulate the effective transportation of both goods and people [27]. All in all, smart mobility aims at establishing and utilizing interconnections between the physical and digital world to leverage traffic data to improve traffic efficiency. For example, sensors in cars or traffic lights can be leveraged using the Internet-of-things (IoT) to facilitate policy makers to generate traffic data to improve decision making [28]. Similarly, IT traffic assets as road signage, vehicle detection systems and vehicle to vehicle (V2V) communication facilitate the management and dissemination of traffic data to improve traffic conditions [29]. Therefore, it is no surprise that this domain has traditionally been characterized by a strong focus on innovating traffic and mobility infrastructure and technology to find sustainable solutions for these ever-increasing challenges.

However, this emphasis on technology innovation and infrastructure development, which can be characterized as *goods-dominant* [30], is slowly changing. This is because end-users are not concerned with the intrinsic technical characteristics of intelligent transport systems or applications, but rather with how these technologies can create value for them when put into practice (i.e., its *value-in-use* or *value-in-context* [31]). As a result, smart mobility initiatives are shifting from a goods-dominant towards a service-dominant perspective, focusing explicitly on how the offered service solution creates value to the end-user [7], [30], [32]. Emerging trends in the mobility domain like *car sharing* show that customers increasingly move away from a goods-dominant perspective (e.g., buying a car) but rather look at the value (e.g., the flexibility and ease-of-use) offered by car sharing applications that provide a similar mode of transportation [33], [34]. As such, adopting a service-dominant perspective can enhance the value of these technology innovations and establish more sustainable solutions for smart mobility initiatives [35], [36].

Considering this shift of emphasis, the role of *business models* to create alignment between consumer value created by the service solution and the assets deployed to create this value becomes pivotal [37]. Moreover, the service-dominant nature of these business models causes these models to become dynamic and short in lifecycle, as customer demands become more volatile and complex due to the intangible nature of the offered services [8], [19]. As a result, these service-dominant business models must be rapidly constructed, deconstructed and reconstructed, placing high importance on the valid and viable design of these models. However, given the broad landscape of potential stakeholders in the smart mobility domain, which include (but not limited to) government bodies and other public authorities, traffic operators, customers (e.g., private or professional drivers and other road users, such as pedestrians and cyclists), service providers, technology providers and various other private companies (e.g., logistic companies, mobile network operators, parking operators) [38], it may prove difficult to identify the stakeholders and respective roles that should be considered, or to explore what roles are potentially missing to offer the proposed service solution. Moreover, as each stakeholder may pursue different goals, it may become challenging to find an acceptable balance (compromise) to ensure that all respective goals are satisfied properly.

However, there is no mentioning of a standardized template or *a reference blueprint for the design of business models* in the literature that features a set of stakeholder categories expected in smart mobility business models, the characteristics of these stakeholders and what business model value outcomes they generate. Such a reference blueprint can facilitate the design of new smart mobility business models and can serve as a basis for both practitioners and business model research to explore the configuration of smart mobility business models. It can facilitate its users in exploring the stakeholder groups that should be considered in the design of the business model, and in mapping the concrete stakeholders to these stakeholder groups. As a result, it can help its users converge more quickly towards potentially valid and viable smart mobility business models. Therefore, we developed a reference blueprint that features a set of expected stakeholder categories including their roles and characteristics, as well as the value outcomes (costs and benefits that they will incur), with the aim to facilitate the design of service-dominant business models in the smart mobility domain.

To develop the reference blueprint, we have conducted rounds of open coding [39] and focused or axial coding [39], [40] on the blueprint business models created as a result of the business model design workshops presented in Table 13. Accordingly, we allowed our codes, which focused on the generic stakeholder categories to be included, to iteratively develop as our understanding of the roles of stakeholders, as well as their interactions within the business model increased. Discussions with participants were collected and noted, allowing the generated data to be coded. We also examined why certain decisions were made with regards to the design of the business model. This resulted in a comprehensive reference blueprint for the design of business models in the smart mobility domain, elaborating the stakeholders to be expected, their value contribution as well as how they capture value from participation.

15.2. Reference Blueprint

Figure 82: Reference Blueprint for the Design of Business Models in the Smart Mobility Domain presents the reference blueprint that we developed. The blueprint is depicted in the form of a service-dominant business model radar [6] and provides guidance mainly for two layers of the radar: actors and the cost/benefits that each actor incurs [21]. For each stakeholder category identified, we elaborate the characteristics of the associated role, and specify the generic cost and benefit items that can be expected from participating in the business model. These costs and benefits can be *financial* and *non-financial* in nature [19], [41]. Moreover, examining the characteristics of each stakeholder category facilitates the users to map concrete stakeholders (specific to a city or area) to these generic roles.

Similarly, given the generic costs and benefits that are expressed per stakeholder category, users can identify whether these costs and benefits are also applicable for their concrete stakeholders (or whether adjustments to the business model design should be made). Note that, because of the generic nature of stakeholder groups, in practice concrete stakeholders may not cover the entire spectrum of characteristics or functionalities which reside in different groups, requiring the multiplicities of the groups to be changed. The proposed set of stakeholder categories include *customers / users, service providers, technology provider, traffic manager, private organizations* and *societal contributors.*

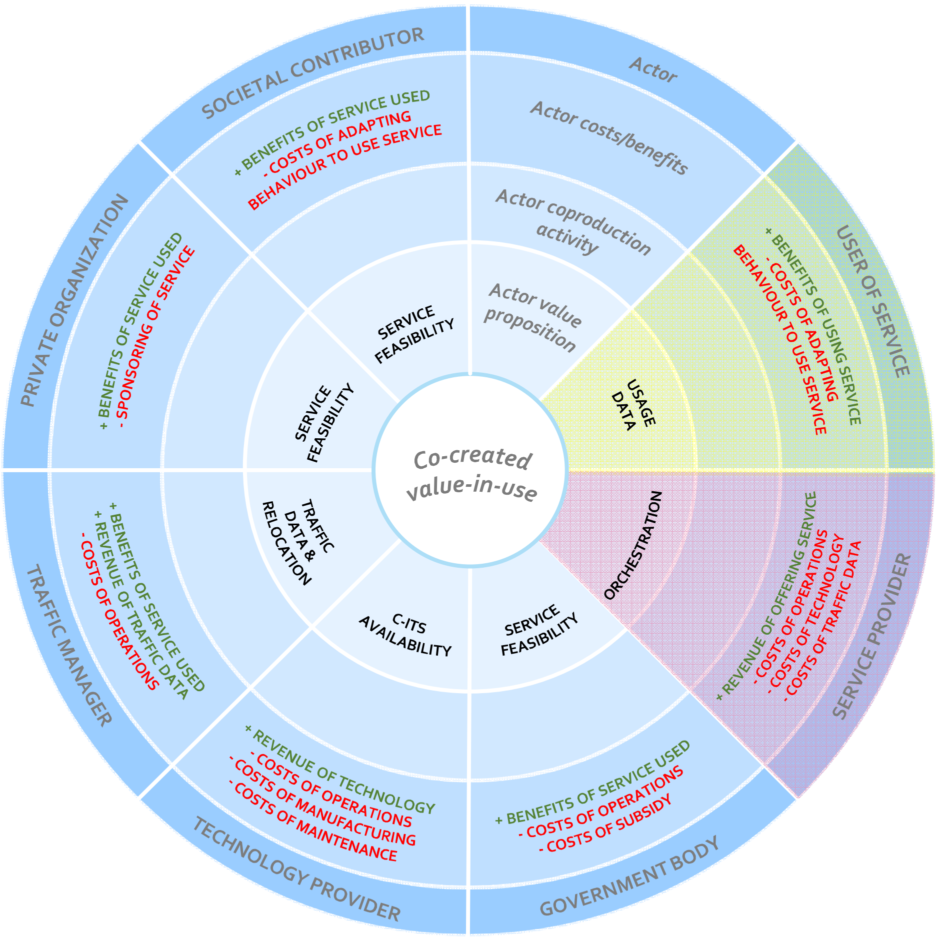


Figure 82: Reference Blueprint for the Design of Business Models in the Smart Mobility Domain

In the subsequent paragraphs, we briefly describe each actor and its role in the reference blueprint.

15.2.1. Citizen / User of the Service Solution

The *citizen* or the end-*user of the service solution* is a key stakeholder in any service-dominant business model and represents the party to which the value created by the service solution is appropriated. The smart mobility business models should include a user group and ensure that the service solution is catered to the end-user. The end-user of the service can be concretized as a car driver, pedestrian, or cyclist. Moreover, this may also be specified further to target highly concrete end-user groups (e.g., elderly pedestrians) or user organizations which act on their behalf (e.g., transport operator). For instance, the business model design might be catered towards stimulating trucks to use outer ring-roads to reach their delivery location instead of the roads in the inner city to relieve the traffic in an urban area. In this case, the logistic company instead of the individual truck driver becomes the end-user of the solution.

Considering our discussions with the workshop participants, the main revenue structure for individual end-users for designing and implementing smart mobility business models should accommodate a 'free' business model for which the end-user does not have to *pay*. This is primarily to stimulate the adoption of service solution and is aligned with the general pattern observed in successful business models in this domain [11]. In this scheme, the costs of participating in the model comprise of the actions the user has to take to use the service (the change in behaviour required, e.g., using a C-ITS service, presenting and offering usage of personal data, or adhering to instructions presented by the service). These costs should be compensated by the benefits that the service solution may provide to the end-user (e.g., increased comfort and safety while travelling or decreased travel times). However, in case of an organization representing these groups of end-users, this revenue model may be catered to a subscription or lease model, depending on the benefits that arise from the service solution.

15.2.2. Service Provider

The *service provider* is the focal organization and 'owner' of the business model, responsible for establishing the interface between the end-user and other business model stakeholders, and orchestrating the service solution. The service provider is also often a platform provider (similar to organizations as Uber). The service provider operates as an information hub, collecting traffic, technology, and usage data to instantiate the service or to disseminate data with regards to service or activity invocations of other business model stakeholders. From our workshops, we identified that service providers are primarily driven by financial opportunities to participate in smart mobility business models. Therefore, the benefits obtained from the business model for the service provider are in the form of revenue generated by offering the service, while the financial costs are incurred for the orchestration and internal operation of the C-ITS-enabled mobility solution. Moreover, depending on whether the service solution requires data to be generated by other stakeholders within the business model (e.g., technology provider, traffic manager), the service provider can also be required to compensate the costs incurred for obtaining this data.

15.2.3. Government/Public Body

Smart mobility initiatives are typically aimed at improving city management [27]. Hence, the inclusion of a *government/public body* is key to ensure the success of a business model. The *government body* can be characterized as a municipality, local, regional or national government. Its role is to support and ensure the feasibility of the business model, which may include operational support (providing the legal means to implement C-ITS technology within cities or complex geographical areas), but also financial support in terms of subsidizations. As the service solution is catered towards solving or improving a city challenge, the main benefit that can be appropriated to the government body are the benefits of the service being used, which may include (but are not limited to) improved traffic conditions, increased safety of the end-user, decreased traffic emissions, and improved liveability, social benefit and image of the city or a district. This is at the cost of the investments or subsidies the government body offers to the orchestrator (the service provider), and the possible initial and operational expenses to support the business model implementation.

15.2.4. Technology Provider

Mobility solutions can involve the deployment of advanced technology solutions including C-ITS, and related components, such as sensors, cameras, road-side units, or communication technologies. The stakeholder category *technology provider* develops, implements, manages, and maintains this enabling technology. The organizations focusing on the development of these technologies can be mapped under this stakeholder category. Our discussions with workshop participants showed that the participation by the technology provider in the business model is driven by the sales of technology (systems, devices, and associated services for their operation, maintenance, update/upgrade, and disposal). Given these characteristics, costs and benefits appropriate to the technology provider are primarily of a financial nature. As benefits, the technology provider generates revenue by selling the availability of technology to the service provider (e.g., development and maintenance), whereas costs are incurred for developing, implementing, and maintaining the C-ITS technology and operational costs with regards to supporting internal business practices.

15.2.5. Traffic Manager

The stakeholder category *traffic manager* is a rather elaborated category, encompassing the responsibility of operating the traffic infrastructure, which may include facilitating the mobility of end-users (e.g., road availability and traffic management). Accordingly, depending on the service solution offered by the business model, the *traffic manager* can be concretized as a road operator, but can also take the role of public transport operator. Based on how the *traffic manager* is concretized, benefits may either relate to the effects of the service being used, or relate to the increase in revenue concerning the transportation of end-users. For instance, in case the stakeholder category is concretized as a road operator to manage the traffic as part of the service solution, the road operator can benefit from the effects of the service solution being offered (e.g., less traffic jams or an increased throughput of cars on the road). Similarly, if the role is concretized as a public transport operator to offer the part of the service solution, the public transport operator can benefit from an increase in user base, as end-users are stimulated to take public transport. Depending on how the category is concretized, the traffic manager incurs costs of internal operations related to supporting the service solution.

15.2.6. Private Organization (or Other Service Providers)

The *private organization* can be concretized by a wide group of stakeholders (including, but not limited to, insurance companies, employers, parking providers, retailers), which may support the feasibility of the business model as these organizations can potentially benefit from the service being used. The service solution can generate valuable user data, endorse traffic behaviour which may benefit the organization, or is catered to a group of end-users which interests the organization. Given the potential benefits of the service solution, the *private organization* can join to further stimulate the feasibility of the business model. For instance, for a service solution that allows employees to arrive at favourable times at work, employers also benefit from the service solution (e.g., increased productivity of workers) [check Section 5 BM02-Comfortable Commuting by Bike]. To ensure that the use of the service solution can be sustained (or even stimulated), the employer can actively support the business model financially. Therefore, they do not actively contribute part of the value of the service solution, but rather ensure that the business model remains feasible. Accordingly, this may be part of *public-private partnerships* schemes to improve the feasibility of the business model [34], [36]. Similar to the *government body*, the effects of the service being used may prompt a private *organization* to become an active stakeholder in the business model and invest in the service solution. As costs, the private *organization* incurs costs of sponsoring or stimulating the service.

15.2.7. Societal Contributor

Although the service solution aims to improve overall traffic conditions within a certain area, the service solution cannot be catered to all customers or end-users (e.g., car drivers, cyclists, pedestrians). However, the effectiveness of the service solution might depend on how well these stakeholder groups interact. For instance, services which depend on detection to avoid collisions with traffic users (e.g., pedestrians) may become significantly more effective to end-users if pedestrians actively contribute behavioural data. In turn, this may also benefit the pedestrian in terms of increased traffic safety. Therefore, the *societal contributor* can be characterized as the party that enhances the service solution by supporting the service. This can be achieved through sharing data but can also be achieved by following up road instructions or traffic signage. Generalizing the previous example, the societal contributor benefits from the service being used (e.g., a decrease in collisions between car driver and pedestrian). As a cost, the societal contributor has to adapt his or her behaviour (e.g., follow up instructions or actively share behavioural data).

15.3. Practical Implications of the Reference Blueprint

The reference blueprint demonstrated in this section elaborates on few key representatives, yet generic stakeholder categories that are expected to take part in the C-ITS business models. We indicated the characteristics and forms that these stakeholders can take in these business collaborations, their functionalities, as well as the costs and benefits that they can expect when they participate. Such a blueprint, applicable to not only C-ITS but also general mobility business models, has been possible thanks to a considerable number of blueprints designed in the C-MobILE project. Although concrete stakeholders, specific for a city or area, may cover various functionalities or roles, the comprehensive set of stakeholder categories encapsulates the basic set of functionalities that can be expected for these models. Taking this blueprint as a reference and a starting point might help companies to rapidly design (more) complete business models. The reference model can also inspire and facilitate the design of novel business models for C-ITS services.

16. Recommendations for Business Model Design

This report presents the final set of business model blueprints, each involving a particular set of enabling or supporting C-ITS services. A blueprint shows the stakeholders that are involved in offering that solution including their contributions and the main costs and benefits involved in the deployment of the solution. It acts as a guideline in understanding and presenting the operative and economic aspects of the solution. The blueprints can be concretized in local sites and by relevant parties, facilitating an open collaboration of stakeholders in an operational way.

From these practical actions, we can derive a set of key action points that we describe in this section to foster service-dominant business thinking in the mobility landscape. We discuss our recommendations in four categories related to respectively the strategic positioning in the domain, application of the service-dominant business paradigm in the mobility, the use of multi-sided business models, and the importance of explicit treatment of non-financial costs and benefits in business models.

16.1. Strategic positioning in the mobility domain

The service-dominant business leads companies towards an important strategic decision about where they position themselves in ecosystems in their business domain. In the mobility domain, the companies can characterize themselves as asset and technology suppliers, service providers (such as the transportation service provider, content provider, navigation provider), government bodies, policy makers and regulators, and network orchestrators. The last type creates and orchestrates a network of companies and other parties including the customer to co-create a value. They keep the main connection to the customer; hence they control the customer intimacy and often have the greatest potential for getting and keeping the customer engaged.

Complex mobility problems require solutions with multiple complementary services that are provided by a network of parties. Such solutions often require parties from each of the stakeholder groups listed above. However, an individual organization (profit or non-profit) should focus its attention and align its strategy to represent only one of these groups. It should choose the perspective in which it excels and leave the rest to other domain players who excel in their own perspective. Trying to combine multiple perspectives in a single player may lead to a detrimental loss of focus.

The workshops performed with many stakeholders have shown a strong need for the presence of privately managed 'network orchestrators' in the mobility domain. Despite a considerable number of players in other stakeholder groups, orchestrators that would act as the main business catalyst are scarce. However, the business models resulting from this action make a convincing business case for companies to re-align their strategy to become orchestrators.

16.2. Application of the service-dominant business logic

The mobility domain can be considered as an asset/product-centric, in which business thinking often starts with consideration of assets, products or technology. Assets can be road-side units, traffic signage equipment and systems, vehicles, and traffic management/information systems, as well as the communication infrastructure and related technology. This often leads to a means-to-goals direction of thinking and an inside-out (provider-to-customer) perception of the market.

However, end customers in the domain (such as road users) are mainly interested in the added value brought by the mobility services or solutions (such as congestion-free travel, safe journey, fast travel) - not so much in the means to accomplish these services. In other words, customers are interested in the proposed obtained by the execution of mobility or C-ITS services - they prefer the outside-in-view. Assets in the domain are certainly required, but to customers they are of secondary interest only. The more complex a market gets, the more different the inside-out and outside-in views become.

We believe that the policy makers and other organizations in this domain should promote the thinking that starts from customer value instead of thinking that starts from mobility means. This means that they should promote customer-centric design of business models (outside-in thinking) instead of provider-centric design of these models (inside-out thinking).

16.3. Multi-party business models

Most business settings in the mobility domain have a multi-stakeholder and relational nature. For example, from the mobility point of view, the organization of a large-scale consumer event involves not just transport providers, vehicles, and road authorities, but also event organizers, security providers, municipalities, parking providers and many more.

In traditional business design settings, collaboration can only be modelled and designed in dyadic, bilateral settings, i.e., by considering pairs of organizations in their business relations. Here, more complex scenarios are created by nesting bilateral relations, typically by means of outsourcing. In contemporary mobility settings, complex business models often only become viable when analysing them directly in a multi-party setting in which more than two parties collaborate at the same level (i.e., to design multi-sided business models). At this collaboration level, several value streams exist between parties that together form a viable business system.

The business model blueprints presented in this report illustrate this point: all have considerably more than two parties at the same collaboration level. Note that this does not mean that bilateral contracts become obsolete: multi-sided business models can be formalized in a set of bilateral contracts (typically between the orchestrator and each of the other parties).

From the above observations, we argue that organizations in this domain should use techniques that enable the design and analysis of multi-sided business models. Policy makers and regulators should trigger organizations to experiment with multi-sided business models in a light, explorative way with multiple stakeholders involved. Experience from our workshops shows that prototypes of business models can be collaboratively designed within a few hours, often leading to interesting new business ideas. Having a moderator who is trained in service-dominant thinking involved in the design process is, however, essential to reach these outcomes.

16.4. Non-financial costs and benefits

In typical business thinking in many domains, the emphasis is often on decreasing financial costs. Sometimes, carbon footprint is explicitly considered, but in many cases, this can be mapped onto financial costs. However, other costs and benefits often are in play as well, which need to be considered to make a multi-sided business model work. For instance, there may be stakeholders that do not have a direct financial benefit in a business model but that are required to make it work; there may be stakeholders that have financial costs that may be offset by non-financial benefits.

For example, public/governmental organizations are expected to emphasize safety and ecological preservation, which are difficult to quantify in financial terms, yet should be considered as non-financial cost/benefit items in business model designs. Another example relates to the value of data. With the increasing attention on data analytics and business intelligence, business data has become more important for organizations and a significant motive to participate in collaborations based on business models that incur direct financial costs but have no direct financial benefits – these financial benefits can be reaped by using the data in other business models.

From these observations we argue that organizations should promote thinking in both financial and non-financial benefits (and costs) in business models. Both types can be exchanged for each other where so required. In doing so, they should start thinking in a qualitative way to keep business model design open, and quantify non-financial costs and benefits in a later stage of business model design. An important consideration is that concrete approaches or standards should be developed to guide the quantification of non-financial costs and benefits related to, for instance- information/data, safety, reduction in ecological impact, image, and visibility.

17. Conclusions

In this deliverable, we report on the final business model blueprints for the C-ITS services deployed in C-MobILE local sites. The initial versions of the models have emerged from the stakeholder workshops at the C-MobILE local sites and reported in the deliverable D2.5. For the final versions of the blueprints, we have continued collaborating with the local sites for the emergence of new blueprints and for the improvement of existing ones, consolidated these blueprints into final set of 10 business model blueprints -each incorporating a set of C-ITS services for the solutions of specific mobility challenges of urban areas. The final business model blueprints are generalized version so that they can be adopted by cities with similar mobility challenges. In addition to providing details of the blueprints, we have performed financial viability evaluation and a survey to evaluate the feasibility of the blueprints.

The business model blueprints are designed collaboratively by various stakeholders in the mobility domain. Several workshops and meetings, as well as the survey ensured that the blueprints address important and relevant mobility challenges faced in C-MobILE deployment sites, which can be generalized to the challenges faced in many cities across Europe. The blueprints cover all C-ITS services deployed in C-MobILE sites.

In this report, we also present a *reference business model blueprint* that we have generated based on the consolidated set of 10 blueprints. The reference blueprint can be used as a template for the design of new business models for C-ITS-enabled mobility solutions. Finally, based on the lessons learned in the design of business model blueprints in the C-MobILE project, we present our recommendations to companies, public bodies, policy makers, and other stakeholders regarding the actions points that should be taken in the business development for C-ITS-enabled mobility solutions.

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Appendices

18. APPENDIX-A List of Business Model Design and Evaluation Workshops Conducted

Table 13: List of business model design and evaluation workshops

Business model workshops	Date
North-Brabant / Helmond, Automotive Campus	27-06-2017
Thessaloniki, CERTH offices	10-07-2017
Copenhagen, City Hall	21-08-2017
Bordeaux, CEREMA offices	28-08-2017
Barcelona, RACC offices	18-09-2017
Vigo, City Hall	19-09-2017
Bilbao, City Hall	20-09-2017
Newcastle, City Hall	22-09-2017
Helmond, Automotive Campus	02-10-2017
Amersfoort	03-10-2017
Bilbao, General Assembly, City Hall	22-11-2017
Eindhoven, TU/e Campus	19-06-2018
Eindhoven, City Hall	27-06-2018
Helmond, City Hall	26-02-2019
Vigo, CTAG Offices	05-12-2019
Video-Conferences	27-01-2020, 07-02-2020, 21-02-2020
Video-Conferences: D4.6 + D6.4 alignment	07-01-2021, 15-01-2021, 26-01-2021
Video-Conference – Helmond	03-02-2021
Video-Conference – Thessaloniki	10-03-2021
Video-Conference – Barcelona	11-03-2021
Video-Conference – Copenhagen	15-03-2021
Video-Conference – Bilbao	15-03-2021
Video-Conference – Bordeaux	16-03-2021
Video-Conference – Newcastle	17-03-2021
Video-Conference – Eindhoven	22-03-2021
Video-Conference – Vigo	23-03-2021

19. APPENDIX-B: C-ITS Services involved in the Business Model Blueprints

The following sub-sections provide brief descriptions of the C-ITS Services incorporated in the Business Model Blueprints. More information about these services and related use-cases are available in the deliverable D2.2 [42].

19.1. S01 - Urban Parking Availability

Urban parking availability provides parking availability information to its users to make informed decisions about available parking places. The service aims to reduce congestion, time loss, pollution and stress caused by cruising for parking. Based on user data and parking availability data in the vicinity of the user (which can be collected through roadside units (RSUs) and / or on-board applications), the service offers an optimal advice to the user (through *in-vehicle signage*) with regards to the nearest available parking space, in order to minimize the search for a suitable parking location. The value of the service can be further enhanced through accompanying *urban parking availability* by *mode and trip time advice* to facilitate travelling from the parking location to the desired destination. This way parking outside of congested areas or high traffic city sections can be made more comfortable.

19.2. S02 - Road Works Warning

Road works warning aims to inform the drivers in a timely manner about road works, restrictions, and instructions. This allows them to be better prepared for potential obstacles downstream on the road, therefore reducing the probability of collisions.

19.3. S03 - Road Hazard Warning

The road hazard warning service aims to inform the drivers in a timely manner of upcoming, and possibly dangerous events and locations. This allows drivers to be better prepared for the upcoming hazards and make necessary adjustments and manoeuvers in advance. (This is also known as "Hazardous location notification" (ETSI, 2009) or 'Road hazard signalling').

19.4. S04 - Emergency Vehicle Warning

Emergency vehicle warning uses information provided by the emergency vehicle to inform a driver of another vehicle about an approaching emergency vehicle even when the siren and light bar of the emergency vehicle may not yet be audible or visible. This is also known as "Emergency Vehicle Alert (EVA)", which alerts the driver about the location and the movement of public safety vehicles responding to an incident so the driver does not interfere with the emergency response. The service is enabled by receiving information about the location and status of nearby emergency vehicles responding to an incident.

19.5. S05 - Signal Violation Warning

Signal Violation Warning aims to reduce the number and severity of collisions at signalised intersections by warning drivers who are likely -due to high speed- to violate a red light. Also known as the "Signal violation / Intersection Safety" or "Red Light Violation Warning".

19.6. S06 - Warning System for Pedestrian

Warning system for pedestrian aims to detect risky situations (e.g., road crossing) involving pedestrians, allowing the possibility to warn vehicle drivers. Hence, the warning is based on pedestrian detection. The scope of the service can be extended to cover other VRUs (e.g., cyclists). The service is particularly valuable when the driver is distracted or visibility is poor. (Also known as "Vulnerable road user Warning"

19.7. S07 - Green Priority

"Green Priority" aims to change the traffic signal status in the path of an emergency or high priority vehicle (e.g., public transportation vehicles), halting conflicting traffic and allowing the vehicle right-of-way, to help reduce response times and enhance traffic safety. The service can be implemented as follows. The green priority request including the identification information of the high priority vehicle can be published via on-board software applications in the vehicle. Consequently, traffic light controllers can pick up this information and determine in what way they can and will respond the request. The same information may also be picked up by road side units (RSUs) and cooperatively communicated to other traffic light controllers on the route of the vehicle or directly to the traffic manager. Different levels of priority can be applied, e.g., extension or termination of current phase to switch to the required phase. The appropriate level of the green priority can depend on vehicle characteristics, such as type (e.g., HGV or emergency vehicle) or status (e.g., public transport vehicle on-time or behind schedule).

19.8. S08 - Green Light Optimal Speed Advisory (GLOSA)

“Green light optimal speed advisory” (GLOSA) or “dynamic eco-driving” provides drivers an optimal speed advice when they approach to a signalized intersection. This advice may involve maintaining actual speed, slowing down, or adapting to a specific speed, allowing the user to reach a green light and minimize fuel consumption and emissions. If a green traffic light cannot be reached in time, GLOSA may also provide information on time-to-green when the vehicle has stopped. Application of GLOSA takes advantage of real-time traffic sensing and infrastructure information to communicate to users an optimal speed advice. The service enables the user to experience more eco-friendly and comfortable driving, as a more regular speed can be maintained, whereas unnecessary braking or stopping can be diminished or avoided which in turn should benefit the environment.

19.9. S09 - Cooperative Traffic Light for VRUs

“Cooperative traffic light for VRUs” or “Traffic light prioritisation for designated VRUs” aims to increase the safety and comfort of pedestrians or cyclists in traffic through warranting priority or additional crossing time (i.e., extending the green light phase or lessening the red phase). As such, a more regular flow or speed can be maintained whilst cycling, improving the comfort of the user. The service can be catered to the needs or characteristics of the user or can be altered for special conditions (such as the weather).

19.10. S10 - Flexible infrastructure

Flexible infrastructure aims to interchange information about the lanes provided to the traffic users according to the time of the day. It includes solutions such as reserved lane.

19.11. S11 - In-Vehicle Signage

In-Vehicle Signage service aims to provide information to the driver about the road signs (and dynamic information, e.g., local conditions warnings identified by environmental sensors). The purpose is to increase the likelihood of drivers being aware of potentially dangerous conditions in case a roadside traffic sign is not noticed.

19.12. S12 - Mode & Trip Time Advice

Mode & trip time advice (e.g., by incentives) aims to provide a traveller with an itinerary for a multimodal passenger transport journey, taking into account real-time and/ or static multimodal journey information. Based on user data with regards to the user’s current location and desired destination, and considering traffic data with regards to density, congestion and flow, the service can provide an optimized multi-modal advice on how to venture efficiently through a specific area. The service enables the user to enjoy a more comfortable and efficient travel experience, as traffic stress can be largely avoided whereas (waiting) time in traffic can be decreased.

19.13. S13 - Probe Vehicle Data

Probe Vehicle Data is data generated by vehicles. The collected traffic data can be used as input for operational traffic management (e.g., to determine the traffic speed, manage traffic flows by - for instance- alerting users in hot spots, where the danger of accidents accumulates), long term tactical/strategic purposes (e.g., road maintenance planning) and for traveler information services. Also known as Floating Car Data (FCD).

19.14. S14 - Emergency Brake Light

Emergency Brake Light aims to avoid (fatal) rear end collisions, which can occur if a vehicle ahead suddenly brakes, especially in dense driving situations or in situations with decreased visibility. The driver is warned before s/he is able to realize that the vehicle ahead is braking hard, especially if s/he does not see the vehicle directly (vehicles in between).

19.15. S15 - Cooperative (Adaptive) Cruise Control

“Cooperative (Adaptive) Cruise Control” (CACC) represents an evolutionary advancement of conventional cruise control (CCC) and adaptive cruise control (ACC) by using V2V communications to automatically synchronize the motion of many vehicles. The service enables the user to experience more eco-friendly and comfortable driving, as a more regular speed can be maintained, whereas unnecessary braking or stopping can be diminished or avoided which in turn should benefit the environment.

19.16. S16 - Slow or Stationary Vehicle Warning

Slow or stationary vehicle warning aims to inform/ alert approaching vehicles of (dangerously) immobilized, stationary or slow vehicles that impose significant risk.

19.17. S17 - Motorcycle Approaching Indication

Motorcycle approaching indication informs the driver of a vehicle that a motorcycle is approaching/passing. The scope can be extended to cover other VRUs, such as cyclists and other Powered Two Wheelers (PTW). The motorcycle could be approaching from behind or crossing at an intersection.

19.18. S18 - Blind Spot Detection/Warning

Blind spot detection aims to detect and warn the drivers about other vehicles of any type located out of sight.

20. APPENDIX-C: Legend for the Choreography Diagrams

A choreography diagram [43] describes business actors and their *interactions* in carrying out tasks. As shown in Figure 83, a choreography diagram consists of a *start event*, an *end event* and *choreography tasks*.

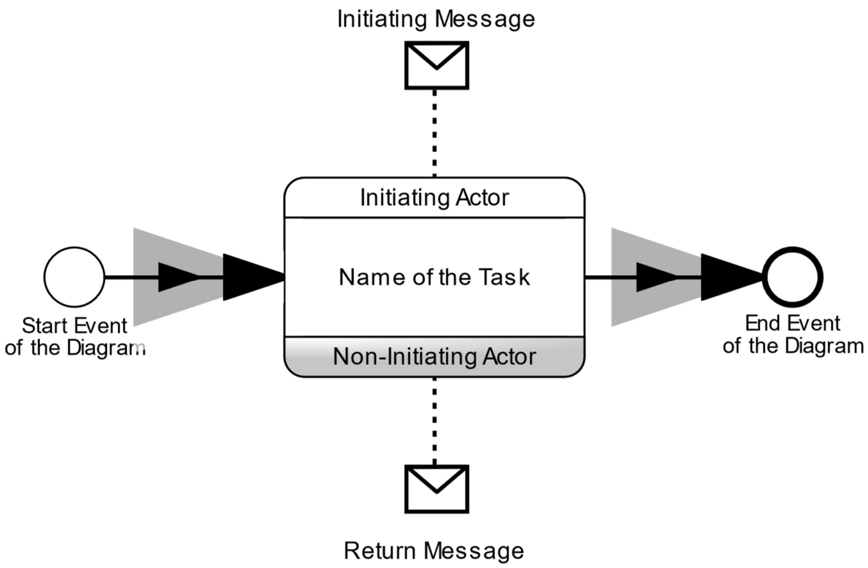


Figure 83: The Legend for a Choreography Diagram

Depicted with the rounded rectangle in Figure 83, a choreography task includes:

- At least two actors, an *initiating actor* (depicted in the same color of the task - white) and a *non-initiating actor* (depicted in gray).
- Messages exchanged between the two actors in carrying out the task. There can be an *initiating message* (connected to the initiating actor) and optionally a *return message* (connected to the non-initiating actor).

The reading direction for choreography diagrams is by default from *left to right* and tasks are placed between the start and end events following the reding direction.

21. APPENDIX-D: Survey on Business Model Blueprints for Mobility Challenges

C-MobILE Survey on Business Model Blueprints for Mobility Challenges

Welcome to C-MobILE Survey on Business Model Blueprints for Mobility Challenges,

The main objective of this survey is to gain an understanding of the views of the end-users and key stakeholders in the mobility domain on the Business Model blueprints (scenarios) that are envisioned to address a number of current and future transport and mobility challenges of urban areas. Your input will help us to develop better solutions to address these challenges.

It takes about 5-10 minutes to complete the survey depending on the number of blueprints/scenarios that you would like to review.

Thank you for your valuable contribution,
The C-MobILE Consortium
https://c-mobile-project.eu

C-MOBILE

The C-MobILE (Accelerating C-ITS Mobility Innovation and depLoyment in Europe) vision is a fully safe & efficient road transport without casualties and serious injuries on European roads, in particular in complex urban areas and for Vulnerable Road Users. We envision a congestion-free, sustainable and economically viable mobility, minimizing the environmental impact of road transport.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723311.

Participation to the Survey
The nature of this survey is completely voluntary. Participants are not forced to take part into the project and no negative consequences will derive from declining the participation. All collected data is anonymous and confidential. Participants won't be identifiable. When filling out the survey, you are free to decline to answer questions on topics and questions that you do not wish to answer/discuss.

Prepared by:
Information Systems Group
Eindhoven University of Technology (TU/e), C-MobILE Partner
Please contact O.Turetken@tue.nl , O.E.Adali@tue.nl for any remark.

Next

Demographics

Please select the stakeholder profile that would represent your perspective in the mobility domain best? (Please maintain this perspective in answering the questions that will follow.) *

Choose

Please indicate the city where you or your organization is located. *

Your answer

Back Next

C-MOBILE

Business Model Blueprints/Scenarios for Mobility Challenges

Below we present a number of business model blueprints/scenarios designed to address mobility challenges of urban areas. Please select a scenario that you would like to review. *

- ◯ 01- Decreasing Truck Traffic Through Inner City (via Green Priority and GLOSA)
- ◯ 02- Promoting Comfortable Commuting by Bike (via Traffic Light Prioritization)
- ◯ 03- More Efficient Fleet Operation (via GLOSA)
- ◯ 04- Hassle-Free Event (e.g. Concert/Match) Experience (via Mode & Trip Time Advice)
- ◯ 05- Green and Comfortable Commuting to Dense Inner-City
- ◯ 06- Safe Driving Experince for Car Drivers (via In-Vehicle Warning Services)
- ◯ 07- Reliable and Efficient Public Transport Operation
- ◯ 08- Efficient Freight Delivery in Urban Areas (via Parking Availability)
- ◯ 09- Faster and Safer Emergency Vehicles (via Green Priority and Emergency Vehicle Warning)
- ◯ 10- Comfortable Walking in Urban Areas (via Traffic Light Prioritization)

**** NOTE: Business Model Blueprints vs. C-ITS Services***

*Cooperative Intelligent Transport Systems (C-ITS) are wireless technologies & applications enabling road users to connect and interact between each other and with traffic managers by exchanging data or messages. C-MobILE project aims to deploy a number of C-ITS services (listed below) to enable the implementation of the solutions to address a number of mobility challenges.

C-ITS Services → Business Models ↓	Urban Parking Availability	Road Works Warning	Road Hazard Warning	Emergency Vehicle Warning	Signal Violation Warning	Warning System For Pedestrian	Green Priority	GLOSA	Cooperative Traffic Light For VRU	Flexible Infrastructure	In-vehicle Signage	Mode & Trip Time Advice	Probe Vehicle Data	Emergency Brake Light	Coop. (Adaptive) Cruise Control	Slow or Stationary Vehicle Warning	Motorcycle Approaching Indic.	Blind Spot Detection/ Warning
Business Model Blueprints	**S01**	**S02**	**S03**	**S04**	**S05**	**S06**	**S07**	**S08**	**S09**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**
BM01 – Decreased Truck Traffic Through Inner City							X	X										
BM02 – Comfortable Commuting by Bike									X									
BM03 – More Efficient Fleet Operation								X										
BM04 – Hassle-free Event Experience												X	X					
BM05 – Green and Comfortable Commuting to Inner City	X						X					X						
BM06 – Safe Driving Experience		X	X	X	X	X					X		X	X	X	X	X	X
BM07 – Reliable and Efficient Transport Operation		X	X				X	X		X	X		X			X		
BM08 – Efficient Delivery In Urban Area	X																	
BM09 – Faster and Safer Travel of Emergency Vehicles				X			X											
BM10 – Comfortable Walking									X									

Vorige Volgende

BM01- Decreased Truck Traffic Through Inner City via Green Priority and GLOSA**

One of the challenges that cities face is the truck traffic that goes through inner city to save time, rather than following the ring roads that are more suitable for such traffic. The through traffic causes inner cities to become quickly congested. Besides, the road maintenance increases as the infrastructure in inner cities are not always suitable for heavy freight logistics. As a result, cities prefer trucks to take the ring roads to avoid traffic, thereby decreasing cost of maintenance, noise, and pollution in the inner city. For truck drivers, however, taking the ring road often means increased travel time and distance. Given this challenge of the conflicting perspectives, a solution should be established in which truck drivers are stimulated to take the ring roads, satisfying the needs of both the logistic companies and the city.

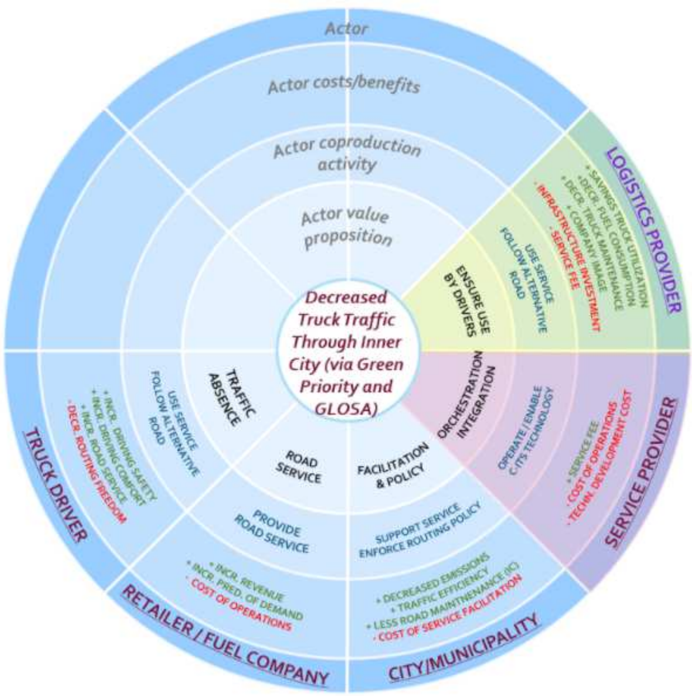
The business model blueprint for a potential solution is depicted above. The solution involves the deployment of a number technology services that offer priority and comfort to truck drivers when taking the ring roads. In particular, it involves the green priority and green light optimal speed advice (GLOSA) services. The green priority service aims to change the traffic signal status in the path of designated vehicles – in this case trucks– in order to help reduce their travel time. GLOSA service provides drivers a speed advice when they approach to a signalized intersection. This advice may involve maintaining actual speed, slowing down, or adapting a specific speed, and time-to-green information when the vehicle is stopped in the light.

Using these technologies in the ring road allows designated trucks (e.g., of a logistic company/fleet operator) to increase their throughput similar to taking the inner-city roads, hence reducing the number of trucks that venture into the inner city. Moreover, as variations in speed are reduced, the logistic company/fleet owner may also benefit from reduced fuel consumption.

The business model is orchestrated by a traffic manager (or a service provider) that takes care of developing and enabling the service, allowing truck companies to achieve the same throughput when taking the ring road as compared to venturing in the inner city. The customer of the business model is the city (or municipality), which benefits from reduced numbers of trucks within the inner city representing the citizens. Consequently, this would lead to a variety of environmental, social and financial benefits for the city. In order for the service to be used, it should ensure that relevant policies are enforced, which would allow trucks (participating in the scenario) to receive priority when taking the ring roads. The city sponsors the service provider for operating and enabling the service, who benefits from the revenues accrued of offering the service. The business model can be enhanced by fuel companies (or retailers) positioned on the ring roads. Such partners might also benefit from increased revenues and increased predictability of demand, as truck drivers are stimulated to take the ring roads instead.

Below are questions regarding the service solution (depicted in the business model radar together with a brief textual description). If you have any remark about any question or your response, please indicate in the text area provided in the last question.

Business Model for Decreased Truck Traffic Through Inner City via Green Priority and GLOSA *



	Very Low	Low	Medium	High	Very High
Q1: To what extent would the proposed service solution (depicted in the business model radar) help in addressing the mobility challenge?	○	○	○	○	○
Q2: To what extent is the list of stakeholders needed for the proposed service solution complete?	○	○	○	○	○
Q3: To what extent are legal or technological barriers present towards implementation of the service solution?	○	○	○	○	○
Q4: To what extent does trust or mutual understanding exist or can be established between actors in the service solution?	○	○	○	○	○
Q5: To what extent can the costs and benefits per stakeholder in the service solution realistically be balanced?	○	○	○	○	○
Q6: To what extent are costs and benefits listed per stakeholder subject to uncertainty?	○	○	○	○	○

Please indicate any remark about the proposed service solution. (This may include barriers, improvements, as well as missing stakeholders, cost or benefit items.) *

Jouw antwoord

**Related C-ITS Services
- S09- Green priority
- S10- GLOSA
-- Please follow the link below for brief descriptions of these services: https://bit.ly/3aKftxr

Vorige   Volgende

BM02- Comfortable Commuting by Bike via Traffic Light Prioritization**

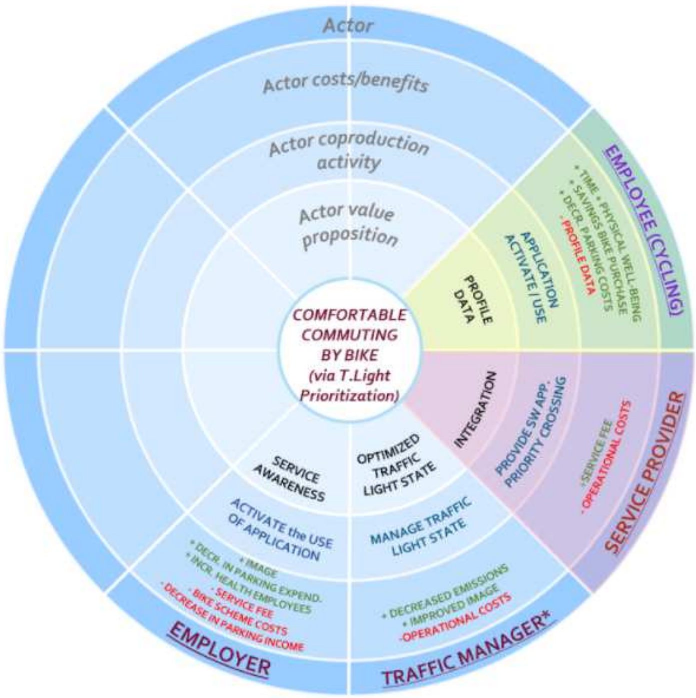
Reducing car traffic in certain urban regions is among the common objectives of many mobility initiatives. In this business model scenario, an employer (an organization or and industrial zone) aims to endorse or stimulate cycling as the mode of commuting for its employees. This is with the aim to reduce traffic in the vicinity of the business premises, and to reduce the need for parking spaces for private cars on location. To foster this, a service provider offers priority crossing for cyclists via a smart device application, which can be activated through software codes. These codes are purchased by the employer, which distributes these codes to its employees commuting by bike. The service can be adapted or customised to fit the needs of the user or the environment (i.e., activating only during rush hours).

In order to operate the solution, the data concerning the location and travel direction of the user (i.e. commuting cyclist) is collected through the smartphone application. The application runs in the background; as such, no interference of the cyclist is needed. Moreover, traffic lights are equipped with the technology to allow software application on cyclist's smart device to interact with the lights. Once the cyclist (carrying a smart device with active application) approaches the traffic light, two scenarios occurs. In case of a red light, increased priority is given to the VRU by activating the green light quickly and allowing the cyclist to continue with reduced waiting time. In case of a green light, the duration is extended to support the flow. The service can be catered to the needs or characteristics of the user or can be altered for special conditions (such as the weather).

The value proposition of this scenario is comfortable commuting by bike to employees who commute (or will commute) by bike. The comfort implies that the cyclist can maintain a regular speed or flow whilst cycling and is either interrupted less frequently at intersections or can more quickly continue his or her journey after a stop.
The business model blueprint can potentially be further financed through including retailers, who may account for a part of or entire service fee, allowing the service to be offered to a wider public. The service generates profile and regular routing information of the cyclists which can be used to provide customized promotions for the commuters. Depending on the policies in certain regions, retailers might be interested in advertising products or services through the application if the data profile shows that cyclists take a route on which the retailer is located or in the vicinity.

Below are questions regarding the service solution (depicted in the business model radar together with a brief textual description). If you have any remark about any question or your response, please indicate in the text area provided in the last question.

Comfortable Commuting by Bike via Traffic Light Prioritization *



	Very Low	Low	Medium	High	Very High
Q1: To what extent would the proposed service solution (depicted in the business model radar) help in addressing the mobility challenge?	○	○	○	○	○
Q2: To what extent is the list of stakeholders needed for the proposed service solution complete?	○	○	○	○	○
Q3: To what extent are legal or technological barriers present towards implementation of the service solution?	○	○	○	○	○
Q4: To what extent does trust or mutual understanding exist or can be established between actors in the service solution?	○	○	○	○	○
Q5: To what extent can the costs and benefits per stakeholder in the service solution realistically be balanced?	○	○	○	○	○
Q6: To what extent are costs and benefits listed per stakeholder subject to uncertainty?	○	○	○	○	○

Please indicate any remark about the proposed service solution. (This may include barriers, improvements, as well as missing stakeholders, cost or benefit items.) *

Jouw antwoord

**Related C-ITS Services

- S11- Cooperative traffic light for pedestrian (Traffic Light Prioritization for Designated VRUs)
-- Please follow the link below for brief descriptions of these services: https://bit.ly/3aKftxr

Vorige Volgende

22. APPENDIX-E: Pricing Strategies Applicable in C-ITS Business Models

In this section, we present an overview of the basic pricing strategies that can be used in the design of business models for C-ITS services. These mechanisms are not mutually exclusive; combinations of pricing mechanisms may be created based on the specific characteristics, users and parties that are active within a business model scenario. The strategies are listed with a decreasing likelihood of use in the C-MobILE C-ITS business models.

Free of charge

Users do not have to pay for using the service [44]. Instead, users may pay for a surplus of service (i.e., freemium) or other sources of revenue (i.e., third-party models as affiliate or advertisement models) are considered, or data with regards to users may be sold to third-party companies. For C-ITS business models, this may imply that the service operator offers smartphone applications for free to its users. Consequently, users are able to benefit from the functionalities that C-ITS services may have to offer. Sources of revenue may be accrued from selling advertisements within the smartphone application or selling profile, usage or location data of the users (which can be generated through the application). Additionally, third-party companies may be interested in stimulating and sponsoring the use of C-ITS services (e.g., employers, insurers or health care organisations). Examples of these models for C-MobILE can already be found for Helmond and Copenhagen.

Purchase

Users pay a fixed price upfront and are consequently entitled to using a service for the remainder of its life cycle (similar to buying a product) [45]. For C-ITS business models, this may imply that customers are required to buy an on-board unit (OBU) as a one-time purchase. After the on-board unit has been installed, customers are able to interact with the C-ITS services and as such can benefit from its functionalities until the service is terminated or changed. No additional costs have to be incurred in this scheme after purchase.

Subscription

Users are charged a periodic daily, monthly or annual fee to subscribe to a service [46]. After a period has passed, users can choose to renew or cancel the subscription. The subscription fee for a time period is fixed and is not affected by usage rates. Also known as flat rate pricing. For C-ITS business models, subscriptions can be included through leasing of on-board units or paying monthly or yearly fees for using a smartphone application which facilitates users to interact with C-ITS services. Within this time period, users consequently can benefit from the functionalities the C-ITS services may offer and can terminate the subscription after a certain time period if they do not desire to use the service anymore. Examples of these models may be found for Thessaloniki.

Pay-Per-Use

Users are charged based on the actual usage or usage rates of a service [46]. This may vary from the number of requests to a service to the duration of using a service. Can also be related to ‘Pay-per-Click’. For C-ITS business models, pay-per use can be applied to charge for the amount of requests for a specific C-ITS service. Especially for private companies (e.g., logistic or transport companies), activating C-ITS services as GLOSA or Green Light Priority can be charged through pay-per-use pricing schemes. This allows these companies to decide when to use the service instead of a more fixed pricing approach.

Freemium

Users receive a basic version of a service for free (with limited functionalities) and can pay for additional functionalities (premium versions) [47]. For C-ITS business models, freemium pricing can be incorporated through bundling of services or through providing additional in-app functionalities. The basic version covers the essential functionalities of the provided C-ITS service, but may be enhanced by including or combining the activation of multiple C-ITS services within the same application (at the cost of paying a premium). Examples of these models for C-MobILE can be found in Bordeaux deployment site.

Pay-Per-Performance

Based on the performance of the service, users pay a pre-defined fixed fee (based on service quality level agreements) [45]. This can be included for affiliate models; i.e., based on how well an advertisement performs, the advertiser pays a proportional fee. For C-ITS business models, pay-per-performance pricing can be included in case the municipality serves as customer to the business model. In such a scenario, the service provider and municipality agree on the implementation of a (bundle of) C-ITS services within the city accompanied by SLAs on the expected performance. Consequently, the actual performance of the services can be monitored which should hint at how well the C-ITS services in the end performed. Based on the earlier made agreements, the service provider is paid respectively to this performance.

Dynamic pricing

Based on the characteristics of the current marketplace (i.e., demand, supply, preferences) users pay a fee which may vary over time [44]. This contrasts fixed fee per activity or time (i.e., subscription or pay-per-use) as this includes variable prices. For C-ITS business models, dynamic pricing may be included to stimulate the adoption of the service by customers. Initial customers as such may be able to buy the on-board unit or smartphone application at a lower price per month (or as purchase price) to stimulate adoption. Once adoption increases (and as such network effects on the throughput of traffic or fuel consumption become apparent), the price of the service may be increased.

Pay-What-You-Want

Users have control over the price they pay for using a service, and determine based on personal experiences how they value the service [48]. For C-ITS business models, pay-what-you-want pricing may serve as additional sources of revenue. In essence, the C-ITS service is offered for ‘free’ to users, but depending on how satisfactory the offered service is, users may be inclined to support the service how they see fit (similar to crowdfunding and crowdsourcing approaches). These additional sources of revenue may be directed at further improving the functionalities of the C-ITS services.