FACULTEIT ECONOMIE
EN BEDRIJFSKUNDE

THE CONGRUENCE BETWEEN VDML AND DAMIAN

A CASE STUDY: IN VEHICLE SIGNAGE

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Student number: 01205468

Supervisor: Prof. dr. Geert Poels
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Master's Dissertation submitted to obtain the degree of:

Master of Science in Business Engineering

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Dennis De Langhe

Preface

Writing this master dissertation was an extensive task that gave me much satisfaction. In this introduction I would like to thank all those who assisted me in this effort.

First of all I thank dr. Ben Roelens for all the time he took to read my thesis project and for his valuable feedback. I would also like to thank Henk de Man and Theodoor van Donge from VDMbee, for their help concerning the possibilities of the value management platform, the constructive cooperation during meetings and their feedback during the different stages of this dissertation. Next I would like to thank Frank Berkers from TNO, who guided me through the possible routes to explore when comparing both approaches and the insights concerning the case. I would also like to thank prof. dr. Geert Poels for giving valuable feedback during the final stages. Finally, I would also like to thank my parents and my friends for giving me moral support.

Contents

List of used abbreviations

BM	Business Model
C-ITS	Cooperative Intelligent Transportation Systems
CSP	Communication Service Provider
DAMIAN	Digital Asset Modeling of Interdependencies in Actor Networks
DDI	Data Driven Innovation
ITS	Intelligent Transportation Systems
IVS	In Vehicle Signage
LTE	Long Term Evolution
MNO	Mobile network operator
OEM	Original Equipment Manufacturer
PND	Personal navigation device
PRO	Public road operator
RA&O	Road authorities and operator
SP	Service provider
TNO	Organisation for Toegepast Natuurwetenschappelijk Onderzoek
UEP	User equipment provider
VMP	Value Management Platform

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1. Introduction

1.1 Context

The surge of the internet has allowed for data to be generated and spread from all over the world. Due its growing importance, there is now more data available than ever. There are many sources that predict exponential data growth toward 2020 and beyond. They are all in broad agreement that the size of the digital universe will double every two years at least. Human- and machine-generated data is experiencing an overall 10x faster growth rate than traditional business data, and machine data is increasing even more rapidly at 50x the growth rate. (Ffoulkes, 2017). Consequently, the effective use of data has penetrated all industries and has therefore become an enabler for doing business. Large, established companies have witnessed the rise of small data-driven agile companies with new innovating business models, which have reshaped the competitive landscape. Most existing companies have adapted their way of working to this imminent rise of data. However, the competitive environment never stops evolving and will become ever more complex. Consequently it will be increasingly difficult for enterprises to keep the pace with their operational and competitive environment. Practice has shown that managers in many cases fail to anticipate or adequately respond to these changes for a number of reasons. One of these reasons is that manager underestimate the importance of these changes, and they may wait too long to respond, or may not respond at all. Not only noticing these changes, but also adopting often fails (Jovanović, 2015).
A lot of research efforts are therefore focused on the identification of methods and the development of tools that can help corporations cope with these changes, such as for example competitive intelligence (Bose, 2008). This is also where business models come in to play, as it is an instrument that allows a company to transform and see the impact of possible transformations before implementation takes place, in order to keep up with the changing environment. The goal of a business model is to provide insights in the processes of a company by making an abstraction of the links between different parts of an organization and the ecosystem in which it operates. It attempts to create a clear view of the organization for all stakeholders involved about how the organization creates, delivers and captures value.

In this thesis, we will investigate the use of two methods for the development of business models, namely the Value Management Platform (VMP) (VDMbee, 2016) and the Digital Asset Modeling of

Interdependencies in Actor Networks (DAMIAN) approach (Nooren, Koers, Bangma, Berkers, & Boertjes, 2014).

The VMP is a tool that is developed by VDMbee. It is based on the Value Delivery Modelling Language (VDML), which is a language developed in accordance with the Object Management Group (OMG) specifications (Object Management Group, 2015). The main reason we choose for a VDML-based tool is because of the increasing interest in value modeling and its anticipated benefits. Additionally, VDML is a relatively new language and every study performed on this language will further facilitate its maturity and acknowledgement. The purpose of VDML is to provide a standard modeling language for analysis and design of the operation of an enterprise with particular focus on the creation and exchange of value. It does this by providing abstraction of the operation of an enterprise that is appropriate for business executives, along with representation of supporting detail for the business analysist.

Current modeling languages that venture to reach this goal often fail to provide an overall view with different focuses on the creation and exchange of value. They each focus on a different part of the business model concept due to their various backgrounds and this prevented large scale adoption of these models in practice. (Roelens & Poels, Business & Information Systems Engineering, 2015) In an attempt to overcome this barrier, the OMG (Object Management Group) issued a request for the creation of a standard modeling language that focuses on the creation and exchange of value, whilst integrating existing modeling languages. This resulted in the creation of the VDML. The VDML modeling concepts thus include an aggregation of concepts that occur in different enterprise-level, business modeling and analysis techniques. As a result, a VDML model can support multiple viewpoints and different abstractions of the design of an enterprise. (Object Management Group, 2015). To facilitate the use of this new standard in practice, there was not only the need to fulfill the objectives formulated by OMG, but also to reduce diagrammatic complexity in both notation and understanding of the model in comparison to its predecessors as the target audience is more extensive. Depending on the stakeholder's role within the organization, a different viewpoint of the business model is required. The Value Management Platform as developed by VDMbee supports this functionality by making it easy to switch between these different viewpoints and reduce complexity through different layers of abstraction. These are features which can provide a significant edge for a company in the continuous struggle to gain a sustainable competitive advantage. It provides a framework for the design of business processes which allows for the analysis of business operations by focusing on the flow of activities and deliverables that produce products or services and the values that are delivered. (Object Management Group, 2015).

The Value Management Platform (VMP) can be seen as the integration of the VDML concepts in a management dashboard that facilitates decision-making. It allows managers to view the impact of different business plans and scenarios before implementation. Moreover, it has the possibility to assess the achievement of value objectives in different scenarios. This could be of value when assessing the viability of data-driven innovations (DDI's) and helping the business to remain agile. It supports the 'continuous business model planning' approach that VDMbee considers essential. This approach states that in order to keep up with your competitive environment, a need for continuous adaptation and exploration of new and existing business models is required. Creating a business model is thus an ongoing approach and needs constant approval and verification, as well as adaptation in correspondence to new trends.

Digital Asset Modelling of Interdependencies in Actor Networks (DAMIAN) is a method developed by TNO (the Dutch organization for Toegepast Natuurwetenschappelijk Onderzoek) in an attempt to deal with the shift from the traditional value chain to the value web. In the value chain, there is only one chain or route of actors who each add value to the final product or service delivered to the customer. In the value web there are multiple routes consisting of multiple actors available to deliver similar services to the end-user. The shift is caused by Data-driven innovations such as personalized mobile advertising, which are made possible by the growing production of data and the social trend towards openness and sharing. This, in combination with technological changes have allowed an alternative development of products and services that share similar characteristics to those of already established markets, leading to the emergence of substitutes. Each of these substitutes are being delivered through the collaboration of different participants i.e. routes. This is important because services that might seem similar towards the end-user, can be subject to different regulation depending on the route they follow through the value web and on the organizations that are involved. (Nooren, Koers, Bangma, Berkers, & Boertjes, 2014). Therefore, it is for both policy makers and the companies that constitute this value web, useful to gain insights in the ecosystem. If a company is confronted with less restricting regulations when following an alternative route throughout the ecosystem, this can have a significant impact on the company's bottom line. On the other hand, regulators must also be able to locate these routes, to maintain fairness amongst the competitors. In established markets there often is already a fair list of regulations. When a data-driven innovation comes to market, there is often a lack of these regulations given their sudden emergence and the very nature of the process of regulation enactment. This may lead to inconsistencies in the value web and can cause potential disruptions amongst competitors that offer similar services but follow a different route and are thus subject to different regulations. DAMIAN thus allows for a systematic analysis of the value web and provides

valuable insights in the effects of regulation that can be useful for both companies and the government. It unravels the many interdependencies between organizations and the different roles they can play when a new data-driven innovation is considered. Furthermore, it presents valuable insights in how content and services are produced, distributed and used. Besides this, DAMIAN is able to determine how regulation affects the interdependencies and the conditions, in which organizations offer their services. In an attempt to facilitate Data-driven Innovation (DDI), TNO developed the DAMIAN method and a supporting tool. In this manner, DAMIAN can serve as a basis for discussions about policy and regulations.
The reason we choose DAMIAN is that currently TNO is looking for methods to expand their DAMIAN approach to model the Data-driven dependencies between the companies in the value web from different viewpoints. The focus of DAMIAN is on the links between the digital assets that participants in a value network offer to provide services to the end-user, and for a lesser extent on the physical assets. They encountered the VDML language for value delivery modeling and are eager to find out if VDML can fill the gap.

The main objective of DAMIAN for a company is thus to identify the most beneficial path in this value web to leverage certain advantages, or in the case of the government, limit possible unfair competition by establishing adapted regulation in each of the different paths. In the VMP on the other hand, the focus lies in filling the gap between strategic planning and business operations for a single company in order to facilitate a business transformation and analysis.

Although VDML and DAMIAN have a different focus, it can be interesting to know if these two methods can be used complementary. This could potentially allow policy makers to reap the benefits that are realized throughout the VMP, such as the ability to view the measurable impact on certain values, when considering the implementation of a new regulation whilst using the DAMIAN method. Enterprises could explore alternative routes throughout the value web and see the impact on their bottom line and other values whilst using the VMP method. The overarching question here is thus how DAMIAN and VMP can support the design and evaluation of business models involving multiple actors, such as relevant in the use case. Can the use of a VDML-based tool help, or potentially be used as a complementary method for the assessment of data driven innovations, as are currently being evaluated by DAMIAN? In this context, the following three questions will be researched:

1) Can the current DAMIAN approach be expressed and supported by the VMP?

2) What are the differences and overlaps between DAMIAN and the VMP?

3) What support for design and evaluation for DDI's does the complementary use of DAMIAN and VMP provide?

The first research question shall be illustrated by applying in detail both DAMIAN and VMP to a case study concerning the topic of In Vehicle Signage. This will provide the reader with a first impression of both methods and indicate the focus of each method. The second research question will be answered by the mapping of differences and overlaps, as well as indicate how both approaches compare and in what specific phases potential benefits can be exploited from their complementary use. Last but not least, the synergetic use of both methods is evaluated by TNO and VDMbee and there is critically assessed whether this could actually be used in practice.

This thesis is structured as follows, first an elaborate description of the case, which is provided by TNO in collaboration with Rijkswaterstaat (the instance in the Netherlands responsible for the execution of national policies concerning national highways and roads), is given. This is the case that will be used to compare the two methods. In the following section, the DAMIAN approach is applied to the case. The next section is dedicated to the application of the VMP on the case. The subsequent sections are dedicated to the comparison and the potential collaborative use of both methods.

2. Case: IVS

2.1 Background

Due to the rise of e-commerce and the current demographic climate it becomes increasingly challenging for road operators to ensure an efficient road network. As the road network and its occupation increases, so does the need to manage. Congestion, safety issues, pollution and comfort are topics that receive increasing attention in the search for new ways to improve the road infrastructure. Intelligent Transport Systems (ITS) have the potential to provide a resolution for these topics. It aims to use the developments in ICT to improve mobility and transportation. Connected Car services and traffic information services are examples of Intelligent Transport Systems services that are already with us. Other relevant examples are automotive diagnostics, which inform the driver when the car needs servicing, and real-time traffic and weather information.

Cooperative-ITS (C-ITS) can be considered as a specific section of Intelligent Transport Systems and is a concept that relies on mutual information exchange between vehicles, or between vehicles and road infrastructure. These transactions of information distinguish Cooperative-Intelligent Transport Systems from normal ITS. In this manner, traffic can be controlled and objectives such as safety and congestion can be addressed. The large-scale introduction of C-ITS in Europe has been prohibited because the supporting mechanisms (e.g., security) have not yet come to maturity. Examples of Cooperative-ITS applications are: road works warning, probe vehicle data, shockwave damping, etc. The goals of these applications are oriented to increasing safety, reduction of traffic jams, and environmental considerations. More specifically, shockwave damping is a system that aims to prevent or dissolve traffic jams by detecting sudden braking and control the speed of the vehicles approaching or leaving traffic jams.

In Vehicle Signage (IVS) is the application on which we will focus in the remainder of this master dissertation. In Vehicle Signage provides the driver with relevant and up-to-date signage and traffic information. This includes both speed limits, but also parking restrictions and other informative signage, dependent on the vehicles to which they apply. For example, a family car does not require information about weight restrictions, but a lorry does. This selective information provision is made possible by infrastructure-to-vehicle communications and vehicle-to-vehicle communications. We consider In-Vehicle-Signage as a ‘day one’ application, because it will be available in the short-term, based on the expected societal benefits and the maturity of the technology. Maximum benefits of IVS can be reached if its penetration is 100% and coverage of the road network is as high as possible. However, even with a smaller degree of penetration, some of the benefits can already be achieved.

Connecting Mobility (Dutch ministry of Infrastructure and Environment) and Rijkswaterstaat (the instance in the Netherlands responsible for the execution of national policies concerning national highways and roads) requested an assessment of different wireless communication technologies on non-technical aspects. This to gain insights in the network and potentially exploit the benefits ITS and Cooperative-ITS provide in the near future. The focus of our study lies thus on the implementation of IVS in the Dutch market, with a focus on the communication technologies.

There are different wireless network infrastructure alternatives for C-ITS cases such as In Vehicle Signage, which are called access technologies. Firstly, ITS-G5 (i.e., delivered over the 5 GHz frequency band) is an adjusted version of the Wi-Fi technology, which can be used to communicate between vehicles and the road infrastructure. It is also known as vehicular-Wi-Fi and can be considered as a dedicated short-range communication technology. Besides IVS, this service can also support other ITS applications such as the electronic payment for parking and tolls, intersection collision avoidance, etc. This will be exploited by the public road operator. Mobile network operators can still provide connected car services and other non-critical ITS services and applications. Secondly, the cellular (3G/4G) communications, based on licensed radio spectrum, can also be the primary data communication platform. In this case, the communication service will be provided by mobile network operators. Connected car solutions that are currently offered by car manufacturers often use these mobile networks (3G/4G). In 2020 5G is expected to make an introduction and ITS is considered one of the main applications that should be accommodated. However, it is not yet clear how 5G will eventually be deployed in networks and services and what the role of mobile network operators will be in future ITS exploitation models (van den Ende, van Sambeek, Berkers, van den Broeck, & van de Sluis, 2016). The last alternative is a hybrid approach, which is a combination of the two previous approaches. Both the ITS-G5 and the cellular centric approach have their strengths and weaknesses. Therefore, a hybrid strategy is worthwhile to consider as it can exploit a complementary use of these technologies.

A more detailed comparison of both connectivity options is added in 1Appendix 1.

2.2 Service delivery process.

The process, starting from registering traffic conditions to the delivery of the C-ITS application, can be described using the following steps (see Figure 1).

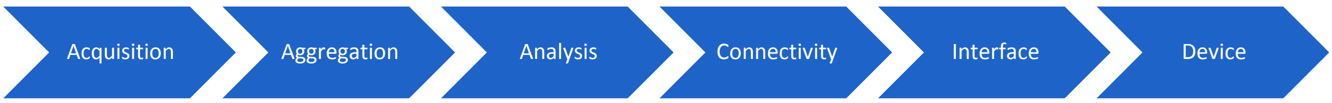

Figure 1: Process delineation

First of all, data have to be acquired (i.e., data **acquisition)** about the traffic conditions. This data can come from several different sources, such as roadway sensors to probe vehicle data, and floating car data. Floating car data are real-time traffic data that is obtained by tracking the location of a vehicle through mobile phones or GPS. These data can anonymously be sent to a central processing center, which we refer to as the data provider. Another possible route for data gathering is probe vehicle data. This means that data is gathered from passing vehicles, using the ITS-G5 wireless service for communication provision. To enable this technology, beacons will have to be set in place that communicate with on-board units in the approaching vehicles. The main advantage is that traffic can be managed more efficiently, since more data is made available for road monitoring. This anonymous data will also provide guidance to where infrastructure investments are required. These data are collected through a network or a local device or database. The quality and configuration of the measurements of each device or measuring system will determine the quality of the data that is used by other parties in the subsequent steps. Therefore, it is important to have a high-quality, reliable and secure system in place.

The refinement of the data is done during the '**aggregation**' step. This refers to the aggregation of the collected data from the previous step and the preparation for analysis. This includes activities such as the proper formatting of the data, removing data that is unreliable or irrelevant, adding an appropriate time stamp and location referencing, making sure that the data can be made available for data processing, etc.

The next step includes the data **analysis**, which depends largely on the quality of the data from the previous steps. Data analysis is the application of several modelling techniques and artificial intelligence methods to transform data into information that is in line with individual driver's needs and preferences. This step also includes formatting the data for the service. The information produced by the data aggregation and data analysis steps, also known as data fusion, is key to manage road networks. The main goal of these two steps is to estimate or predict traffic characteristics and patterns. Nowadays in the industry this usually happens through learning mechanisms of an AI. This analysis can go further than solely the simple detection of vehicles to predict congestion or to detect incidents. Based on the weather conditions, for instance, it can also make an accurate prediction of the condition of the road surface.

The analyzed data has to be transmitted to the end-user. To enable this transmission, there is need for a **connectivity** service. Here two wireless connectivity options will be considered, as discussed in section 2.1. The first being the 4G-LTE network operated by the mobile network operator, and the second being the network operated by the public road operator using the dedicated short range communications ITS-G5. This will provide a data link from the roadside apparatus towards the public road operator and to the road users. The cost of the communication network infrastructure can be up to 50% of the whole cost of the specific ITS system.

The connectivity using ITS-G5 can be provided through roadside ITS stations. These are stations that transmit information about traffic signs to passing vehicles. Of course, one roadside ITS station can cover a certain area and "transmit" details of multiple road signs and other traffic information. It is thus not necessary to have a station for each single sign. We can distinguish three different ways in which these roadside ITS stations are operated. The first is a standalone roadside ITS station. These are used to transmit certain static information to drivers in a certain area, for example a maximum speed limit. The second application are roadside ITS stations, which are part of a dynamic stand-alone system. In this case, there are sensors in place that permit an autonomous system to detect for example accidents or fog. When this is detected, the system automatically lowers the maximum speed, which is sent to the passing vehicles using ITS-G5. The third option is the one, on which we further focus in this master dissertation. The messages that road users receive can be directly adjusted by the road operator. This allows for a dynamic and centralized control of the traffic flow.

End-user interface, also referred to as **app or website** relates to the information displayed on the in-vehicle displays and devices of the end-user. How the information is displayed can have a great impact on the way the service is delivered. This includes choices as making the information automatically visible by ‘pushing’ it towards the driver, letting the driver indicate which information he wishes to receive (‘pull’), or perhaps a combination of both. It is also important to consider how the notifications appear. For example, a sudden loud notification can scare the driver and result in a sudden movement of the vehicle that impairs his own safety and that of his fellow road users. Another discussion concerns which information is obliged and which is optional. These are decisions that are largely influenced by policy makers with respect to existing standards and regulations. A last issue is how to use the different sources of data, such as public sector data, commercial and proprietary data, information branding…

The **device and operating system** designers and manufacturers provide the device on which the service is delivered. They possess the knowledge and manufacturing experience to produce devices that apply to the standards that the public road operator imposes.

2.3 Roles

Close coordination and clear delineation of each of the roles and parties is critical to ensure a smooth implementation and maximal driver benefits. The division of roles will be sent out within a legal framework where public institutions are involved. If we consider the development process for C-ITS applications, the main roles include: data provider, road authorities and operators, ITS service provider, communication service provider, user equipment provider, and end-user.

The **Data provider r**eceives raw data during the acquisition step, which is processed and forwarded to the road authorities and operators in the aggregation step. The data provider categorizes the different kinds of data and puts it in the right format. This includes removing unreliable or irrelevant data, as well as adding a location and time stamp.

Road authorities and operators make use of roadside cameras and sensors to monitor and manage the traffic. They dispose of a wide range of infrastructure and systems to perform their activities to ensure a smooth traffic flow. As such, they have insights in the bottlenecks and locations that are responsible for traffic jams or that need adjusted signalization (e.g. a school zone right after school hours), and they know where the road infrastructure is outdated and needs improvement. The regulations and standards, with which the manufacturers of the on-board devices have to comply, are developed under supervision of the road authorities and operators. They receive data from the data provider and an AI with learning abilities applies algorithms and other IT prediction systems to forecast traffic jams and accidents, and to determine adjusted speed limits and other signalization. The road operator is also responsible for deciding which information is mandatory and what is optional.

The ITS service provider provides the data driven service to the driver, which includes information about adjusted speed limits and other relevant traffic signalization that is made visible on the end-user device on-board. To provide this service, the provider requires the analyzed data from the public road authorities and operators, connectivity, and visibility on the on-board unit. Without the services provided by the service provider, the devices of the user equipment providers would be useless. The service provider can provide these services either for free (this is likely to result in a high level of penetration) or charges drivers a monthly fee.

The communication service provider provides communication services between the ITS service provider and end-users by providing access to their network for both parties. We will consider two alternatives here: mobile network operators for 3G/4G and roadside network operators for ITS-G5.

The user equipment provider manufactures the on-board unit that the driver requires to receive the C-ITS applications. The end-user needs the necessary equipment to support C-ITS applications, such as either (i) a smart phone with subscription to a 3G/4G and 5G communication service provider and to the app from the service provider, (ii) an after-market device, similar to a GPS device, that connects the driver to the roadside network either through ITS-G5 or mobile communication services, or (iii) a pre-installed device in the vehicle, provided by the car manufacturer, who outsources the production to an original equipment manufacturer.

The end-user is the driver that uses the data-driven service. He indirectly delivers input to the data acquirers and the road authorities and operators.

2.4 Models

If we combine the roles and processes, we can identify three different alternatives that can be considered to provide the IVS. The main difference between these models lies in how the connectivity service is provided. Besides this, there will also be differences in the user equipment providers and in the service providers. The different models are named based on the connectivity accessibility of the IVS.

	Model I: ITS-G5	**Model II: Cellular**	**Model III: Hybrid**
Data Provider	PRO	PRO	PRO
Service Provider	PRO	Multiple	Multiple
Delivery Channel	ITS-G5	4G	4G + ITS-G5
Communication Service Provider	PRO	MNO	MNO + PRO

Table 1: Main actors and their roles.PRO: Public road operator, MNO: Mobile network operator

We will apply the VMP and DAMIAN method on elaborately on Models I, while Model II is added in the appendixes in order to illustrate the application. A gradual and specifically targeted introduction of ITS-G5 technology (Model I) is the most realistic scenario for the Netherlands according to TNO. The third model (the hybrid approach) can have different interpretations concerning the development trajectories. Hence what hybrid should mean exactly is not yet determined. Therefore this model is left beyond consideration and is only mentioned for completeness.

2 DAMIAN

2.1 Introduction

As mentioned earlier, the traditional value chain is transforming into a 'value web'. This value web is different as there are multiple routes that seemingly similar services can follow. Each of these routes can be subject to different types of regulation. Organizations in a value web search for opportunities that allow themselves to gain a competitive advantage over their competitors. A TV broadcasting station, for example, is often subjected to stricter regulations than providers that use the internet. Broadcasters, who make their content available through on-line channels, have to comply with rules on the amount of commercials and the protection of minors, while other providers of on-line video services are not subject to these rules (Nooren, Koers, Bangma, Berkers, & Boertjes, 2014). Therefore, regulators need a clear vision of how their policies and regulations can affect the balance of power in the value web. In other words, It is important that all parties and policy makers are on the same page to allow a more productive and efficient discussion. DAMIAN can help to reach this goal.

Figure 2 outlines the steps in the DAMIAN method: identify trigger, determine scope, identify actors, draw routes, identify assets, assess assets, identify regulation, identify tensions and issues, discussion, and explore what-if scenarios. (Nooren, Koers, Bangma, Berkers, & Boertjes, 2014) In the following sections we will illustrate the use of the DAMIAN method by applying it to the case of IVS.

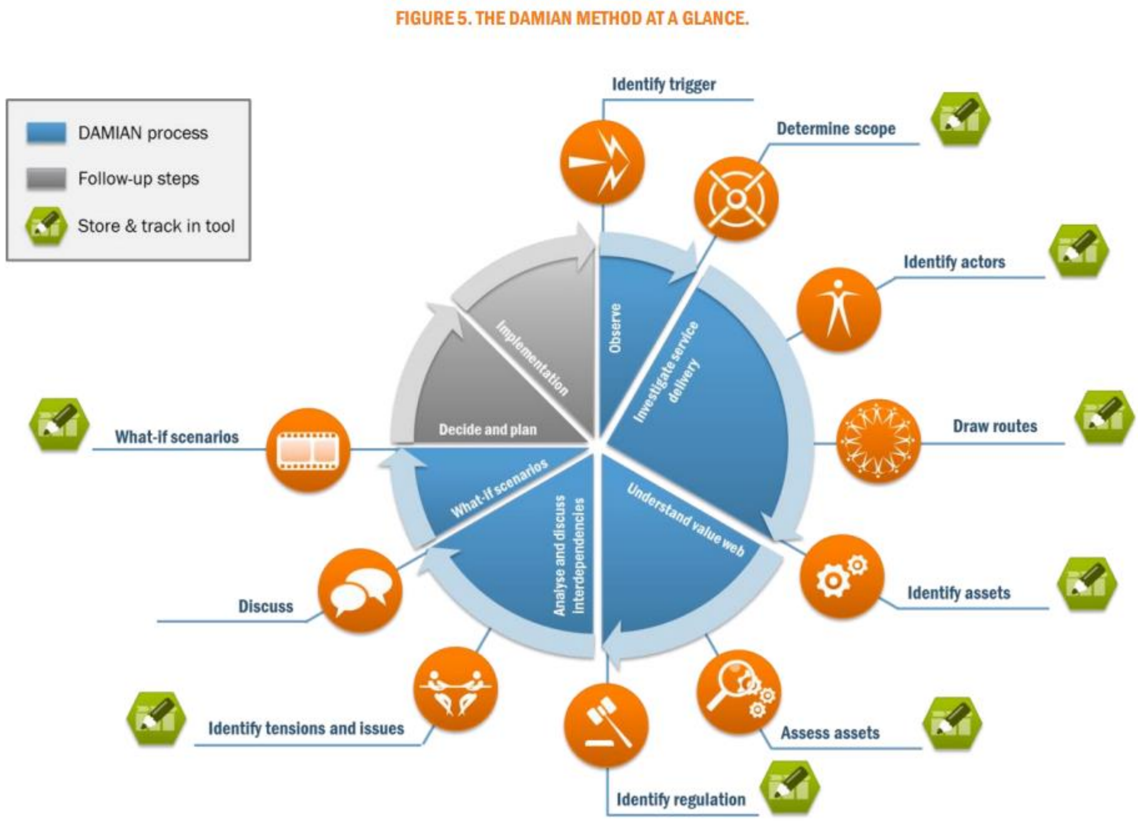

Figure 2: DAMIAN Method (Nooren, Koers, Bangma, Berkers, & Boertjes, 2014)

The stepwise approach as presented in Figure 2 helps to make sure that all relevant elements are taken into account when discussing regulations, reducing the short-sighted focus on specific points that, for example, receive a lot of media attention.

One of the most important benefits of DAMIAN, which was mentioned by participants in workshops, was the support of a more productive and efficient discussion. This was mainly due to the service delivery canvas view. The scoring of alternatives and openness of the assets also gives a first base for discussion, which helps to identify whether differences in scoring are the result of radically different views or of a different perception of the same situation.

2.2 Damian applied to In-Vehicle-Signage

We will apply the DAMIAN method to the first model (i.e., Model I), explained in section 2.4, while the service delivery canvas of Model II is added in 1Appendix 2. The first model describes the situation, in which the public road operator takes the monopoly of the services and uses the ITS-G5 connectivity service to provide the data-driven services to the end-user.

2.2.1 Step 1: Identify Trigger

The starting point of the DAMIAN method is to identify a current case that causes tensions in the market. This case is also called the 'trigger'. This trigger is evaluated by presenting the benefits and drawbacks that can potentially influence implementation.

In the transportation systems market, current connected car services, such as navigation and traffic information services, are already widely adopted. However, these services only represent a fraction of the applications that ITS can provide. Current connected car solutions mostly rely on the 4G LTE network for communication. In this context, the dedicated ITS-G5 access layer technology could be a case that causes disruptions, since its short range WLAN standard is especially developed for ad-hoc broadcast communication between vehicles and to the road side infrastructure. By providing direct communication with a very low latency, it has the potential to support critical road safety applications where fast and reliable information exchange is necessary.

The 4G LTE and the ITS-G5 development is making the development of trigger C-ITS (i.e., a Cooperative Intelligent Transportation System) possible. C-ITS is expected to introduce many use cases, which can be classified into three main categories; safety, efficiency and comfort. The following five seem most relevant for implementation in the Netherlands: road works warning, probe vehicle data, In Vehicle Signage, traffic light control and shockwave damping. IVS can be considered a safety application which also enhances traffic flow. It provides information to the driver that is typically received through traffic signs along the road. This trigger can steer the current exploitation model of Rijkswaterstaat into a new direction. Potential benefits of IVS as mentioned by van den Ende, van Sambeek, Berkers, van den Broeck, & van de Sluis (2016) include:

- Public Road Operators can easily change the speed limit (e.g. during rush hours, when accidents are detected, during opening and closing hours of a school, during roadworks, when the visibility or road surface is affected by bad weather conditions, etc.). This can either happen manually or via autonomous detection systems.
- A reduction of infrastructure investments and maintenance costs. If the coverage and penetration of IVS is high enough, road signage will become less important and can be reduced, or perhaps even omitted, on some places. If a change in signalization is required on certain locations the controlling authority can adapt the R-ITS-Signage messages that are provided to the vehicles from a centralized location and as such avoid the costs of road workers changing the traffic signalization.
- Information is based on time, location, and characteristics of the vehicle (e.g., signage for trucks is sometimes different than those for regular cars) to only send relevant information to the driver. This reduces unnecessary distractions by superfluous traffic signage.
- The continuous stream of relevant information increases the driver's awareness. With today's signalization, the driver is aware of the signage in the awareness area, but this signage is often not repeated during the relevance area. The awareness area represents the area in which the signage is visible for the road users. Often however, this awareness area does consistently overlap with the area to which this signage is applies (i.e. the relevance area). The signage is often consistently repeated during the relevance area, but there are often gaps. IVS can fill these gaps by constantly providing the right signage on an in-vehicle device, resulting in an increase in road safety. Figure 3 illustrates the difference between the relevance and awareness area.
- As the road operator has a clear and detailed view of the real-time traffic, he is able to see where issues might arrive. Thanks to the IVS, appropriate action can be taken such as an adjustment of the speed limits to ensure a smooth traffic flow and to reduce congestion. This results in less traffic jams and reduced pollution that is caused by the continuous braking and accelerating of vehicles.
- The IVS system lowers the threshold and can potentially add value for automated driving in the future. Currently the modern cruise control systems and the software controlling the self-driving vehicles rely mostly on cameras and sensors to adapt the speed of the vehicle. Such systems are error prone and rely on external factors (for example visibility of the road signs). The IVS system can provide a reliable communication channel to send data to the vehicles' automated driving system. Although the built-in systems who recognizes road signage will always be needed for areas lacking the IVS infrastructure, the addition of a reliable data source will increase the overall safety of the automated vehicles. Additionally one can think of applications where the data provided by the IVS system, interacts with GPS systems to

guide the vehicle to less congested roads. Such applications require a reliable high speed data transmission and, even more importantly, timely and accurate information on the road conditions. All these things is exactly what the IVS system can provide.

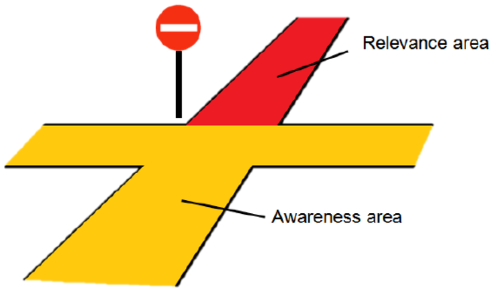

Figure 3: the difference between the relevance and awareness area ((Amsterdam Group, 2016)

There are however some arguments against the implementation of the IVS service, namely:

- There are a lot of investments and subsequent maintenance required to provide a reliable service. This includes roadside ITS stations, road sensors, and the devices in the vehicles.
- This automatically leads us to the question of how penetration will be achieved. One might wonder if drivers will be willing to buy a device themselves, or if these will be subsidized by the government. Is there a possibility to execute IVS on a European level to include foreign drivers in the whole system?
- Benefits mostly appear on the societal side, but are not equally distributed among shareholders. There are alternative routes that need to be examined to make it more attractive for private companies and commercial service providers.
- Deliberate obstruction of access to the ITS channels can cause serious security issues. Jammers, for example, are cheap and have the ability to disrupt the normal working of the IVS and other related ITS applications. In the case of ITS-G5, this poses an even larger problem than for cellular or public Wi-Fi provided services, since there is no back-up radio frequency channel, which makes it extra susceptible.
- Some drivers will ignore speed limits, which results in an inefficient working of the whole system.
- Some countries and individuals might regard the gathered data as personal, raising issues of data protection and privacy.
- The attainment of a high coverage and penetration level will take time. Cars will have to be modified, infrastructure and devices will have to be built. In addition, Car manufacturers will not

invest in these devices if they are not sure that the infrastructure will be put in place. So launch time has to be limited by making the IVS as attractive as possible. This can for instance be done by letting the device also offer other service that would give the end users other added values.

2.2.2 Step 2: Determine scope

The scope consists of the set of end-user (retail) services and their distribution models that are considered important by the involved stakeholders. As mentioned earlier, there are three different possibilities of wireless communication services that are considered for the distribution of information: PRO controlled (i.e., the ITS-G5 technology), Cellular only (i.e., the cellular 3G/4G technology) andhybrid (i.e., a combination of the two former technologies).

2.2.3 Step 3: Identify actors

This step is oriented towards the identification of the relevant actors or participants that will play a role in providing the data-driven service. The table below depicts the main actors and their roles in each of the possible models.

	Model I: ITS-G5	Model II: Cellular	Model III: Hybrid
Data Provider	PRO	PRO	PRO
Road Authority & Operator	PRO	PRO	PRO
Service Provider	PRO	Multiple	Multiple
Communication Service Provider	PRO	MNO	MNO + PRO
User Equipment Provider	PRO + OEM	OEM + PND provider + Mobile Phone provider	PRO + OEM + PND provider + Mobile Phone provider
End-user	Driver	Driver	Driver

Table 2: Main participants and their roles in each of the models. PRO: public road operator, OEM: original equipment manufacturer, PND provider: personal navigation device provider, MNO: mobile network operator.

The public road operator, who takes the role of data provider in each of the models because of its legal authority. This role also helps to facilitate implementation and ensures a uniform stream of initial data.

The original equipment manufacturer is a subcontractor, who is put in charge by the car manufacturer to deliver devices that can be pre-installed in the car.

The mobile network operator, who provides the connectivity service in models 2 and 3. This participant will make use of the 4G LTE network to provide connectivity to both the end-user and the driver as well as to the service provider(s).

The provider of personal navigation devices should incorporate the IVS capability both for stand-alone and built-in versions. These after-market devices can then be considered as alternative for pre-installed devices in the car.

The **mobile phone provider** can provide ITS-G5 connectivity in its devices and support the platform, on which the services are delivered by the service provider.

The **end-user** is the driver, who receives the service in exchange for an eventual fee, depending on the specific model.

2.2.4 Step 4: Draw routes

In this step, the purpose is to identify the functional relationships that exist between the responsible organizations. The visualization of these routes is given in step 5. In Figure 4, a simplified version of the data flows through the value web is given. This does not imply that there is only one route, but it does represent the general flow that similar services will follow.

Figure 4: representation of the actors responsible for the data flow required to deliver the In-Vehicle-Signage

2.2.5 Step 5: Identify assets

The goal of this step is to identify the assets that the organizations use and exchange to deliver the service. Assets in DAMIAN are intangible capabilities or resources that are possessed by actors. These assets are derived from the process that was discussed in section 1.2, which we briefly repeat here. The assets that are represented by DAMIAN are intangible and are not obliged to be measurable.

Data acquisition. How data is acquired is not further elaborated in this DAMIAN example, since the focus lies in the connectivity technology that is utilized to provide the data-driven service.

Data aggregation. Data sources are combined and prepared for analysis. This includes activities such as categorization and adding a time and location stamp to allow for an efficient analysis.

Data analysis. Data are analyzed to provide useful information. The data, which are received during the aggregation, is used in combination with IT algorithms and prediction systems to forecast where adjusted signage is needed to allow for an efficient road network and to prevent accidents. Beside this, the focus lies in the distribution of relevant information to the vehicles. For example, the weight limit on roads for lorries is not relevant for the driver of an SUV, the speed limit is different inside or outside a school zone, warnings should only be given in the zone where fog occurs, etc. This kind of personalized information would be provided by an AI in order to provide the driver with relevant information based on vehicle characteristics, location history and other parameters. Similar services are already put in place, think of personalized advertisements of Zalando and Bol.com based on browser history.

App and website. The information that is shown to the end-user and the way in which the information is displayed. This is the asset that is delivered by the service provider(s).
Device and operating system. The device and operating system, on which the service is consumed by the end-user.
End-user. The automobilist, who is subjected to the ITS services.
Connectivity. The technology that is used to transport the data between the components described above. As stated earlier, we will discuss two connectivity options, ITS-G5 and cellular connectivity.

These assets form the skeleton of the service delivery canvas as shown in Figure 5. The service delivery canvas is structured as follows. The dark grey arrow boxes on top of the figure represent the linear chain of activities. These can be seen as a categorization of the assets. Each of these activities adds value to the next. Simply explained, the assets describe what the activities require in order to be performed. As mentioned earlier, in order to perform the data analysis (activity), the data first has to be aggregated (asset), which is then followed by the analysis (asset). These assets are represented in the light grey vertical columns. These two assets are the components that constitute the data analysis activity. To provide the data visualization, there is need for an app or a website, but also a device on which the app or website is shown. The app and website is made visible to the end user on the device through the connectivity provided by the communication service provider. The dark blue spheres represent the participants. A participant is linked to another participant with a colored line. These lines are the routes that can be followed for the delivery of the service. An asset that contributes to an activity can be provided by different actors. The existence of several actors that possess similar assets is what causes the presence of different routes throughout the ecosystem. If we follow the yellow route, data is aggregated from the temporary signage and is sent to the traffic management, who analyzes the data before it is sent to the next participant. Connectivity is required for the information to be sent to the "NDW" or the central repository, who discloses the information. The public road operator distributes the messages via the after market devices it administered in order to achieve the desired penetration. The ITS-G5 stations provide the connectivity from the repository to the devices. It also possible that roadside equipment shows dynamic messages (e.g. variable message signs such as matrix signage), or that there is already a pre-installed device in the vehicle provided by the original equipment manufacturer. These alternative routes are indicated with a different color. There are three different routes through which the driver can receive the information. Through dynamic roadside equipment, a device designed by the public road operator, or a device that is already built-in the vehicle and is provided by the original equipment manufacturer. Depending on the route that is followed, a different regulation may apply.

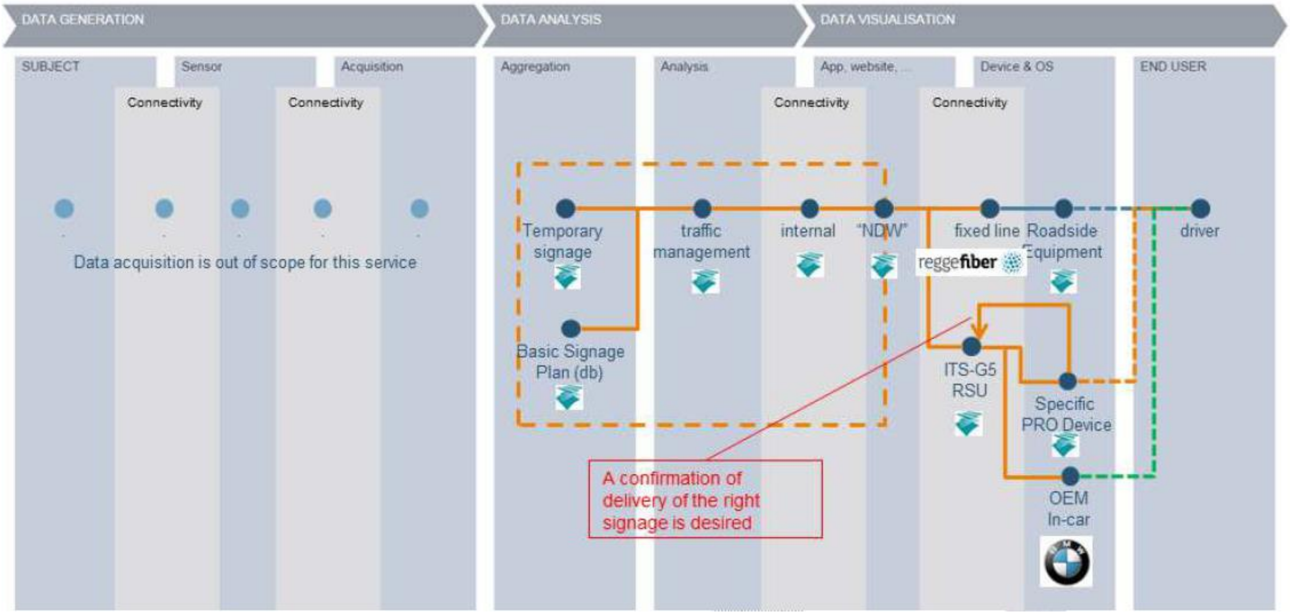

Figure 5: the service delivery canvas for model I: ITS-G5.

2.2.6 Step 6: Asses assets

Assets determine where and how organizations exert influence, capture value, and generate revenues inside the value web. The actor that is in possession of an asset can leverage this to its advantage, depending on how scarce it is or how much it would cost other organizations to obtain the same type of asset. The DAMIAN method uses two scales to score the assets:

- How open is the asset for use by other organizations?
- How many alternatives are available for the asset?

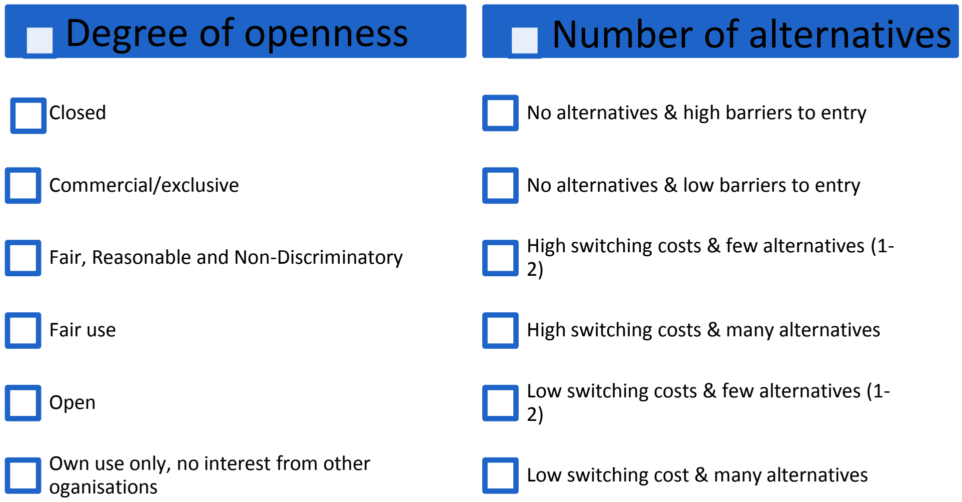

Figure 6: Scoring dimensions of assets in DAMIAN.

These two questions need to be scored by several experts in the field. This scoring is an important aspect of DAMIAN, since it is part of the basis for discussion about regulations and policies. The interview was however not performed in this study due to the uncertainty of the technology and differing interpretations of its implementation.

2.2.7 Step 7: Identify regulation

In Europe, standards are being developed by the European standardization organizations, the European Telecommunications Standards Institute, and the Comité Européen de Normalisation. These standards will help policy makers to wield a uniform regulation policy to reduce disadvantages for any of the organizations in the value web and also to provide more insights in what the service might look like. However, it is not apparent to assess the consequences of the implementation of new regulation because of the many links in the service delivery canvas between the organizations. A rule that seems to make sense at one position in the web can have adverse consequences in other parts (Nooren, Koers, Bangma, Berkers, & Boertjes, 2014).
The specific regulations concerning the GHz band that is used for the different C-ITS services is shown in Figure 7. In Vehicle Signage is a safety and traffic efficiency application and will be assigned the 5.875-5.915 GHz frequency band if ITS-G5 is chosen as communication service. In model 2, where the communication

service is provided by 4G, another frequency band will obviously be used.

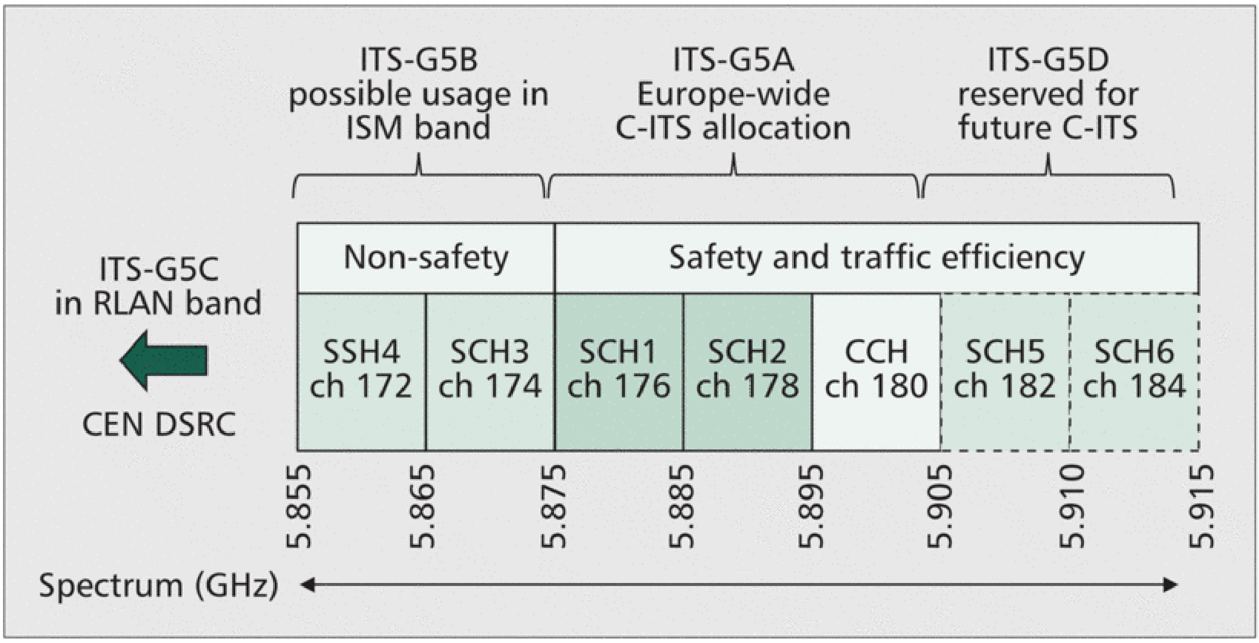

Figure 7: European frequency allocation for road safety and traffic efficiency (ETSI EN 302 571) using the ITS-G5 wireless technology.

Privacy regulations will have to be put in place such that information on vehicle location and speed can be anonymously sent through encrypted messages to the data provider. Without permission to gather these kind of data, the many C-ITS applications, including In Vehicle Signage, will be impossible to implement in the near future. Regulators will have to make sure that the privacy for all drivers is guaranteed, independent of the route they follow in the canvas.

Besides this, standards and regulations are needed concerning the visual appearance of the human machine interface, as well as how this device will send notifications and present these messages through the app or website. It is also worth considering which information is mandatory and which is optional, which can be specified in 'must-carry' rules that oblige the service provider to show certain information. It is also important to ensure that the presented information is consistent and not contradictive in the case of multiple service providers.

To make the business case more attractive for mobile network operators in the context of cellular 3G/4G technology (i.e., model II), it might be permitted to advertise on the IVS service. In this case, rules are needed concerning the content and the amount of advertisements. Another option to make the service more attractive would be through the introduction of subsidies, either for users or vendors of these devices or services.

Other types of regulations that can be added are regulations that aim to lower the threshold for switching between service providers as well as rules on switching between providers and regulations concerning the obligation of a device for foreign drivers.

2.2.8 Step 8: Identify tensions and issues

In this step, we use the overview that was created in the previous steps to identify and discuss tensions in the value web by applying filters in the DAMIAN tool, which can combine the following criteria: the openness of the asset, the amount of alternatives, and the specific policies and regulations and possible conflicts between them.

In the IVS case, the openness in Model I can be considered to be very low, which can be seen as an inconsistency with the openness of the app and website. The public road operator has a lot of influence, because the other organizations are completely dependent on his service since the absence of any alternatives for ITS-G5.

In Model II there are several competing mobile network operators, which will prevent certain providers to exert too much power in the value web. The openness of the 4G network is thus much higher, as are the amount of alternatives. However, other issues, such as price fixing between these providers, must be addressed to enable the market to reach an equilibrium through natural competition.

2.2.9 Step 9: Discuss

In this step, the scoring of the different assets is discussed. Since this scoring by experts was omitted in this thesis, we will assume that there was a general consensus around the openness and the amount of alternatives for each of the assets. This discussion is used to help clarify possible inconsistencies in some of the scores. The inconsistencies can be the result of different insights or knowledge of participants about the subject, or the specific perspective of the assessor.
It is also important to note that the DAMIAN method does not aim to come to a single right score. This score is meant as a starting point for the discussion about (new) policies and regulations and their interdependencies. This discussion is as important as the scoring that precedes it.

2.2.10 Step 10: What if scenarios

This is a non-mandatory step that involves the exploration of alternative routes, organizations or regulations that have the possibility to expand or influence the created value web. Possible scenarios that could be considered in the case of IVS are:

- What if the public road operator wishes to control the speed by using the IVS service, making speed cameras redundant?
- What if mobile network operators want to include other services such as an emergency or breakdown messages?
- What if another participant group is added (e.g., assurance companies), who want to link their prices to the usage of the device?
- What if device penetration is not high enough and the public road operator wishes to increase this penetration by subsidizing device manufacturers to reduce the price of devices to end users?

3 The VMP approach

3.1 Introduction

The Value Management Platform (VMP) is a software platform that is developed by VDMbee to close the gap between business and IT. It allows the business to describe the strategic directions and initiatives that it wants to pursue in the near future, as well as how the company operates within its ecosystem. By doing this, it facilitates to explore alternatives and to take well-considered strategic decisions. In order to realize this, the VMP requires a detailed understanding of the activities that each of these participants performs to deliver its values. The final result easily allows you to view the impact of different scenarios on the plan values, which is the essence of presenting a clear view on all the risks and possibilities of a new plan for the stakeholders of the company.

The VMP is based on VDML, which is a modelling language that is intended to be the standard for all business modelling languages by combining the strengths of several individual languages. In this manner, past experience and knowledge is re-used in the new modelling language. The VMP software extends VDML as it allows to model how different businesses can evolve over time by envisioning different plans and phases that companies run through during the implementation. On the other hand, VMP does not exhibit the same expressiveness as VDML since there are some VDML constructs that are not supported.

3.2 VMP applied to In-Vehicle-Signage

VMP distinguishes between three phases (i.e., discover, prototype, and adopt) to implement the strategic plan of an enterprise. In this context, it is often desired to start with an "as-is" representation of your business before proceeding to a "to-be" setting. As our case can be considered a Greenfield situation (a completely new system that is designed from scratch), we shall start with modelling the "to-be" situation. This modelling effort can be continuously adapted in a dynamic competitive environment as VMP allows to easily create new scenarios. Following the application of IVS through the DAMIAN method, we elaborate on how the first model (i.e., Model I: ITS-G5) can be implemented in the VMP.

3.2.1 Discover

When modelling a "to-be" situation, the discovery phase is considered to be particularly important. Lots of information needs to be acquired to minimize further discussion concerning possible ambiguities in the subsequent phases. In other words, this phase is oriented towards obtaining a general agreement concerning the business ecosystem. This means getting insights in the participants and their different roles, what capabilities and competencies these participants possess, the goals they aim to achieve, what their contribution is towards the value propositions and how they are intertwined with each other. This information is gathered in different ways, such as web research, discussions, brainstorm sessions, interviews and market research. Although this might seem a lot of work, similar methods require the same amount of work in order to gather relevant information required to gain insights in the businesses. When the 'downloading' of information is over, it has to be structured so all stakeholders are on the same page. VMP suggests the use of several templates and tools. These include the business model canvas, business model innovation canvas, the integrated reporting canvas, the lean change canvas, the lean startup canvas, the personal business model canvas, the business ecosystem map and the SWOT analysis canvas. We shall discuss four approaches that include two of these integrated tools.

3.2.1.1 Mission, vision and strategy

The first template is one to clearly depict the mission, vision, and strategy of the organization. This is important because it facilitates the identification of plan values, which can be used for measuring the success of plan outcomes. These values can be financial (e.g., profit) or intangible indicators (e.g., customer satisfaction). The mission, vision and strategy of the first model in the IVS case study is as follows:

WHAT (mission) *Mission* is a statement about your core purpose, why you exist, and is best stated in the present tense.	Rijkswaterstaat is responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. This includes the main road network, the main waterway network and water systems.
WHY (vision) *Vision* is a statement about your desired state, where you want to go, and is best stated in the future tense.	Optimize traffic conditions and inspire other governments to undertake similar projects. Demonstrate the practical possibilities of C-ITS applications and identify further data-driven opportunities to improve road safety and traffic flows, and to reduce infrastructure maintenance costs and emissions.
HOW (strategy) A *strategy* includes the long- and short-term goal and provides information about how these goals will be achieved.	Achieve a high market penetration and coverage of the road network by providing the service and devices at an affordable price, in combination with a high reliability and accuracy of the service.

Table 3: Mission, vision and strategy of Rijkswaterstaat and their IVS service.

3.2.1.2 Business model canvas

Another tool that is suggested is the business model canvas. (Osterwalder & Pigneur, Business Model Generation, 2010) This is arguably one of the best known tools for gaining insight in the blueprint of a business as it provides a clear view of a company and the main drivers of value. Furthermore, its simplicity makes it possible to make a draft of an organization rather quickly, which facilitates possible changes during explorative discussions. This framework describes a business through nine building blocks. Figure 8 depicts the business model of the public road operator in the role of service provider, which will be referred to as the PRO-SP model. The VMP incorporates the implementation of this business model canvas in the app.

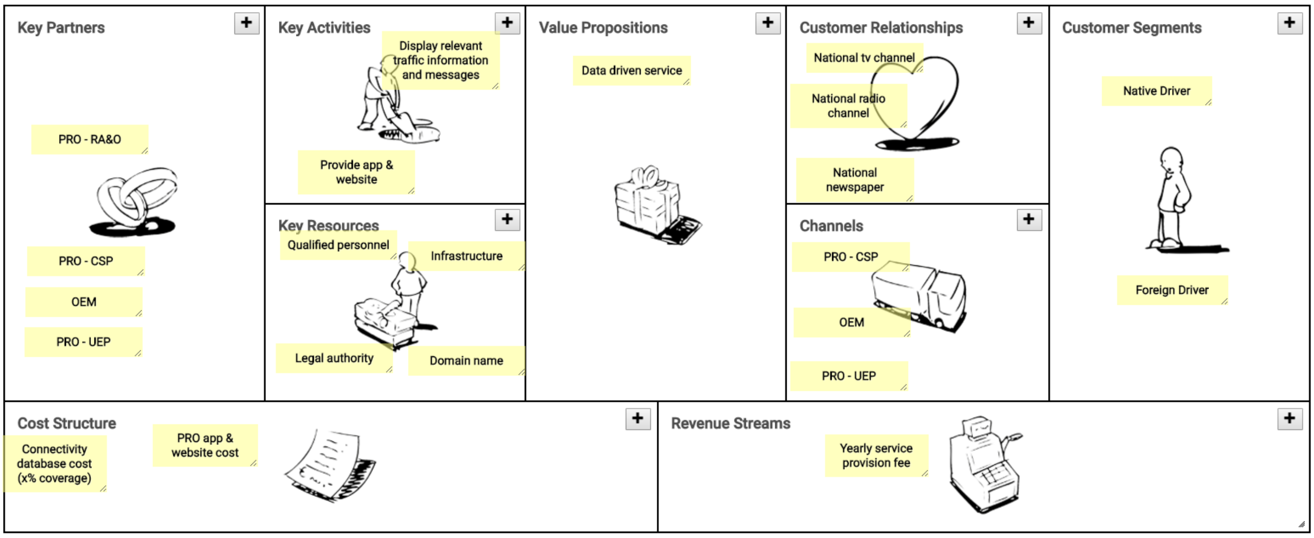

Figure 8: Business model canvas from the viewpoint of the PRO-SP.

The public road operator in the role of service provider will have to partner up with other organizations in order to provide its data-driven service. First of all with the road authorities and operator (*PRO-RA&O*) to provide insights in regulations considering the service that will be provided, the original equipment manufacturer, to allow compatibility of the platform that the service provider designs, with the functions the device will require. A similar partnership will be practiced with the division of the public road operator in charge of the device provision, the user equipment provider (*PRO-UEP*).

The key activity of the service provider is to *provide the app and website*, on which it displays relevant traffic information and messages. The value proposition provided towards its end users is the *data driven service*. In order to maintain a good relationship with its customers, it is important that the service provider monitors the customer satisfaction. This is an aggregated value and can exist besides, or be aggregated from, smaller values such as the security of the channel, the safety increase, environmental benefits and improvement in traffic flow. Some of these values overlap. For example, an improvement in traffic flow will certainly have an effect on CO_2 emissions, and a secure and accurate delivery of the signage will result in an improved safety etc.

The channels for the delivery of the service is of course the *ITS-G5 connectivity*, which is provided by the communication service provider. The *devices* are another essential channel that is required. Other channels to reach customers such as the state magazine or public television channels is left out of consideration. The customers can be categorized into two segments, the *native drivers* and the *foreign drivers*. Obligation of a device can be restricted to native drivers. This will however weaken the possibilities of IVS and raises the question for a European wide introduction with unified regulation in the different member states. The revenue streams for the service provider will largely depend on *subsidies* by the government and possibly a *yearly service provision fee*, which can be linked to the insurance policy of the driver. The costs for the service are separated in two categories. The *connectivity database cost*, and the cost for the *PRO app & website*. These consist of infrastructure combined with initial development costs. In addition there is the cost of maintenance and continued development & app improvements which mainly consists of personnel costs. The customer relationship segment deals with how the customers will be acquired, retained and how sales will be boosted. Two scenarios can be considered here. In the first case the device is obliged in every vehicle by the road operator. This would result in a high penetration percentage. The second option, which is perhaps more realistic is that the use of this device is optional, but heavily subsided by the government. Assurance companies can potentially provide discounts to drivers if they use the devices, in order to promote penetration. We have considered the second scenario, by which the government will make use of national television channels and newspapers to reach their customers. Key resources required for the data-driven service are of course the infrastructure and qualified personnel, but also the authority that the road operator has in order to deliver the service, which uses data that is observed from the road network and speed limitations that are regulated by the government.

While this business model representation delivers a lot of insights, it lacks a view on the links and exchanges between the different organizations, as well as on the roles and responsibilities of each of these organizations. Furthermore, there is also no support to model measurable goals, as this is not the main goal of this canvas. The VMP addresses these issues by making it possible to link the business model canvas to values in the business ecosystem map and the model generated during the prototyping phase. In this manner different relationships can easily be visualized, and by doing so VDMbee offers added value to these kind of canvases.

3.2.1.3 Business ecosystem map

To meet the additional needs of the discovery phase, the business ecosystem map is used. The VMP provides the possibility to link this map to the business model cubes generated in the prototype phase. This facilitates the process and ensures consistency throughout the whole platform. Through this linkage, every participant, business model, value proposition, participant network etc. is automatically created in the Prototype phase, which facilitates ease of use and lightens the burden for the modeler, as it eliminates any double work.

Figure 9 represents the ecosystem map of the case as created in the VMP. It provides more insights in how the business models of the different organizations are intertwined and what the role of each of the participants is. To provide a link with the VDML participant networks, color coding can be used in the business ecosystem map. Although the addition of color coding is not mandatory, it facilitates the prototype phase in the VMP. A participant network shows the values that are exchanged between participants. The participant networks that are described in Figure 9 are *Data (pink)*, *IVS (blue)*, *ITS-G5 (green)*, *Fabrication (yellow)*, *Outsourcing (red)*, and *Device (purple)*. Each of these networks has a specific aim. For example, the *Data* network in purple concerns the process of data delivery, analyzing and processing towards the service provider. The *ITS-G5* participant network in green contains all value exchanges the communication service provider has with the end user and the service provider. *Fabrication* contains the links in which the fabricators have to measure up to standards and regulations concerning the device specifications. The vehicle manufacturer outsources the device and operating system to the original equipment manufacturer (OEM) in the *Outsourcing* network. *Device* is the participant network in which the device and the supporting services are delivered to the end user.

The main benefit of these networks is that they can be reused along different business models to reduce complexity. If you create a new business model, you can use the participant networks that are already present in the previous model. A business model is thus normally based on multiple participant networks. In addition, participant networks provide the user the ability to decompose the often very complex business ecosystem into smaller parts to use for analysis. This provides a more focused insight in the exchanges and the give and take patterns of the organizations.

We can see in Figure 9 that the business model of the *PRO-RA&O* contains participant networks *Data* and *Fabrication* (it is linked with pink and yellow arrows to other participants). The participant network *Fabrication* can be re-used to model the value streams from the *PRO-UEP* and the *OEM*, since these streams appear in the business model of both of these participants. This will be further illustrated in section 3.2.2.

It is not only in the business models of Model I that participant networks provide links. When we switch to Model II we can clearly see that the participant networks overlap (1Appendix 13) .This also makes it easy for the user to identify where the differences lie in each model by first looking at the differences in each of the participant networks.

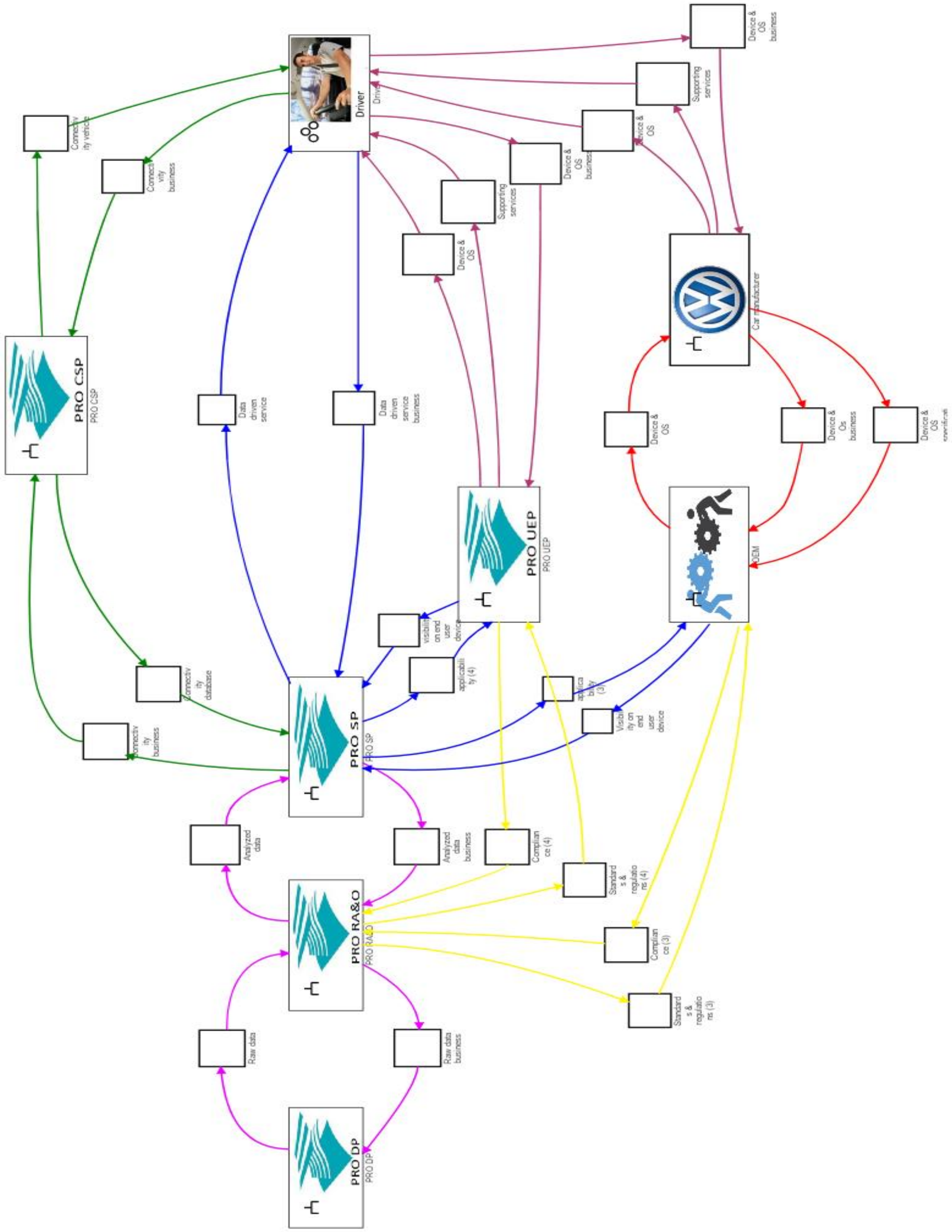

Figure 9: Business ecosystem map (Model I: ITS-G5)

When we zoom closer in on Figure 9 we can see that the public road operator as service provider (*PRO SP*) provides the In Vehicle Signage, or *data-driven service* to the driver. The reciprocal value proposition offered from the Driver to the service provider is the *Data driven service business*. These reciprocal value streams that end in ‘business’ recur in multiple value exchanges. They define or determine demand for what a value proposition delivers. VDMbee suggest to name these kinds of value propositions as the receiving value proposition + ‘business’. In order for the public road operator to provide the data driven service, first of all he requires *visibility on the end-user device* which is again provided by the user equipment provider (*PRO-UEP*) and the original equipment manufacturer (*OEM*). Secondly he needs *analyzed data* which is provided by the road authorities and operator (*PRO RA&O*). By providing the data-driven service, the road operator also makes sure that the devices are useful, which ensures the *applicability* of the devices. These exchanges of value are grouped in the *IVS* participant network. If we look at the road authorities and operator (*PRO RA&O*) we see that he receives *raw data* from the data provider (*PRO DP*) and transforms this into *analyzed data* before sending it to the service provider (*PRO SP*). He also provides standards and regulations to both the *PRO UEP* and the *OEM*, to which they have to comply. The original equipment manufacturer (*OEM*) provides the *device and operating system* to the car manufacturer, who provides him with the required specifications of the devices. These specifications include subjects like interface options and device dimensions. Both car manufacturer and the user equipment provider (*PRO UEP*) deliver the device and operating system to the driver, alongside with supporting services such as warranty. This is grouped in the *Device* participant network. Lastly the communication service provider (PRO CSP) provides connectivity to both driver and service provider through the roadside ITS stations.

Each of the participants in Figure 9 of which we would like to see its values in different scenarios or alternatives has a business model. This makes sense, and also means that for certain participants it is not required to have a business model. In the VMP it is possible to model certain participants as a ‘black box’. How then to decide which participants need a business model? The answer is simple: If you want to see the results of all the value propositions this participant delivers and receives, and/or view the impact of different scenarios on its values from the perspective of this participant, then this participant requires a business model. If however it is not required to see the values from the point of view of this participant, then this model is not relevant and the participant should be modeled as a ‘black box’. The IVS as modeled in this dissertation used business models for most participants, since the change of regulation can affect each of these participants and it is thus useful to see how each of their values change if another type of regulation is applied. 1Appendix 4, Figure 26 represents which of the participants were modeled with a business model.

3.2.1.4 Strategy map

The strategy map is another method which suggested by VDMbee. The canvas describes how the organization creates value. It provides a visual representation of the components of an organization’s strategy, which can be used as a checklist (Kaplan & Norton, 2004). It gives a first indication of the causality between the different values and which factors are important to achieve objectives.

Figure 10 represents the strategy map for the IVS service provider. Logically some of these values overlap with those discussed in Table 3. The service provider aims to have a low cost and a high device penetration, accompanied with an accurate service. The service aims to reduce emission and increase the road safety, which are valued by both the road operator and the customer. Besides that, the customer also values a low yearly fee, which increases penetration but has a negative effect on revenues. Emission reduction and safety increase is a direct result of the efficiency and accuracy of the data delivery and the accuracy of the service delivered. In order to achieve high device penetration, the government will use the national media and subsidies. The low cost to the government depends on the data driven service cost, which in its place depends on the cost of the app and website provided by the service provider.

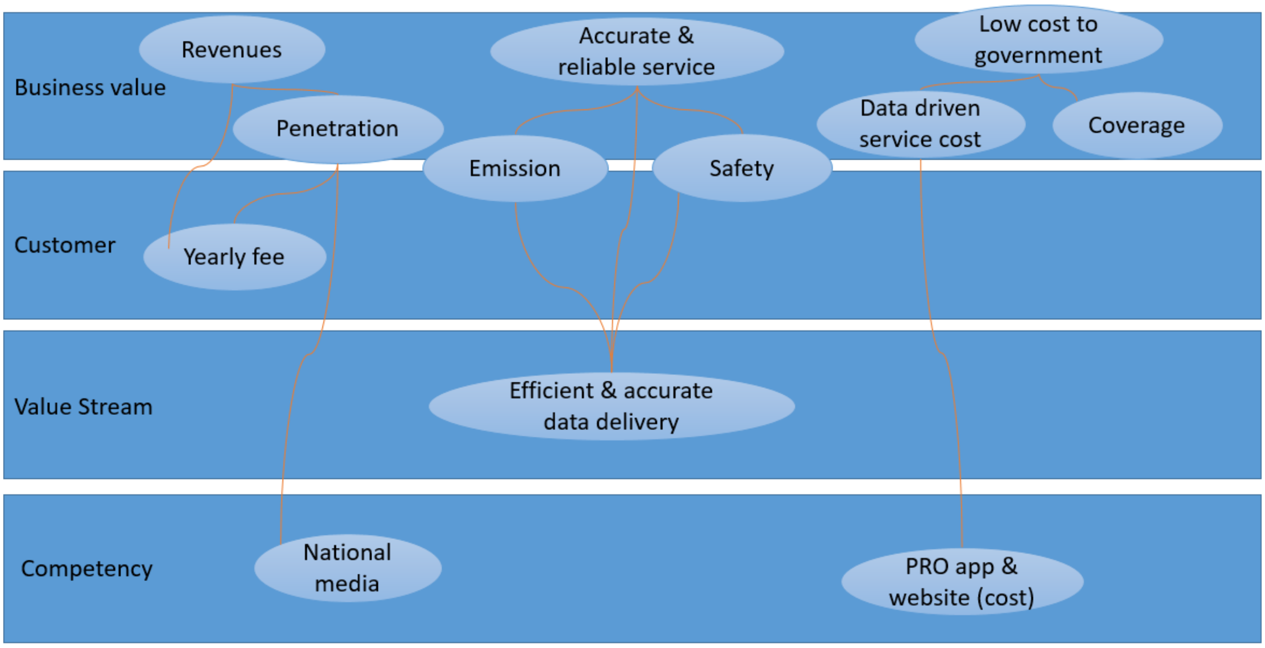

Figure 10: Strategy map of the IVS service provider.

The visual representation and the insights it provides concerning the links between values, prove very useful when going to the prototype phase. It gives a first indication of important values and how these are intertwined and will be aggregated in the prototype phase.

3.2.2 Prototype

The prototype phase is divided in three main activities: planning (3.2.2.1), designing (3.2.2.2), and measuring value (3.2.2.3).

3.2.2.1 Planning

In this activity, it is important to name the plan as well as to decide on possible transitional phases and alternative scenarios. These scenarios can be worst-case or best-case scenarios, but also back-up scenarios. In addition to this, we also define (preferably measurable) success factors and other objectives that ensure a successful implementation. The division of a plan into one of more phases is a feature that is added to the VDML 1.0 specification (Object Management Group, 2015) to account for a constantly changing competitive environment. Consequently, plans might need to be adjusted or implemented through a phased approach to increase the chances of a successful outcome. A phased approach can allow the user to 'test' the market during the earlier phases and change the prototype in response to the market's initial reaction.

We have named the plan 'C-ITS' and assumed that there are two phases needed to reach the desired penetration level of 70%. A one-phased approach of our plan would not take into consideration that penetration can take several years after the first year of introduction. This would affect certain values (such as revenues) and it is thus important to take this into consideration. The first phase (Phase 1: 50% Penetration) assumes a 50% device penetration, the second phase (Phase 2: 70% Penetration) a 70% device penetration.

There are three alternatives considered, which represent the different models of connectivity provision as discussed in section 2.4. In the remainder of this section, we will focus on the ITS-G5 alternative. The Cellular alternative (Model II) is added in 1Appendix 14.

Plan	Phase(s)	Alternative(s)
C-ITS	Day 1 application: IVS	ITS-G5 Cellular (Hybrid)

Table 4: Plan, phase and Alternative(s) of the C-ITS application In-Vehicle-Signage

To model the whole ecosystem, several business models are required for each of the organizations. This results in six business models, one for each participant. These business models are listed in Table 5.

Business	Business Model
PRO - RA&O	Data
PRO - SP	IVS
OEM	Device OEM
Car manufacturer	Vehicle
PRO - UEP	Device PRO
PRO - CSP	Connectivity

Table 5: Businesses and their business models according to Model I: ITS-G5

In the subsequent steps, we shall only perform the necessary activities for the IVS business model. The results for the other business models are added in 1Appendix 4 to 1Appendix 9.
The measurable success factors that are required for implementation of the C-ITS plan are also referred to as plan values. Values are what value propositions are composed of, and can thus automatically contain not only positive values, but also negative values, such as cost, waste… Examples of these include customer-, shareholder-, employee-, financial-, and sustainability- values. Based on Table 3, we can already identify some of the plan values that will be used to assess the success of the plan. One of these is penetration, which measures the percentage of the registered vehicles that are equipped with the device. This measure is relevant as the higher the penetration, the more efficient the whole system will be and the easier the expected benefits (see section 2.2.1) will be achieved. Other values that can be derived are the cost to the government, the reliability of the devices, the accuracy of the service, the safety increase provided by these devices, etc. The complete list that was used in the model is added in 1Appendix 3.

3.2.2.2 Designing

During the design activity, the business model and its main components are explicitly depicted in the software tool. To represent the structure of a business model, the Business Model Cube is used as an appropriate framework. In the next paragraphs, we will go through the different dimensions to illustrate the 'designing' activity from the perspective of the PRO-SP in the IVS case. The design process needs to be repeated for all business models that are presented in the business model canvas to map the whole system into the VMP app. Of course some of the data that needs to be implemented is the same for several business models. This is where the benefit of participant models comes in to play, because they can be re-used across different business models.

The first dimension is the participant network, which includes all participants and their corresponding roles. According to the business ecosystem map (see Figure 9) the PRO-SP (i.e., the organization that provides the IVS business model) is part of three different participant networks. This corresponds to the amount of different colors of the value propositions he exchanges in the map in Figure 9. In each of the participant networks, the PRO-SP plays another role (i.e., analyzed data receiver, data transmitter, and service provider). Table 6 shows how the participant networks can also be represented in the VMP app. If the business ecosystem map in the first phase is linked, this table is generated automatically. It shows us the different participant networks from the perspective of the PRO-SP. In the *Data* participant network, the

PRO-SP assumes the role of *analyzed data receiver*. He partners with the PRO-RA&O. We can also see that another participant of this network is the PRO-DP. The same can be said for the ITS-G5 network. The PRO-SP in the role of *data transmitter* partners with the PRO-CSP and another participant of this network is the driver. In the IVS network the PRO-SP assumes his role of *service provider*, as he provides his service to the customer. In order to achieve his service delivery, he needs the devices provided by the PRO-UEP and the OEM.

Participant Network	My Business (Role)	Customers (Role)	Partners (Role)	Other Participants (Role)
Data	PRO - SP (Analyzed data receiver)		PRO - RA&O (Road operator)	PRO - DP (Data provider)
ITS - G5	PRO - SP (Data transmittor)		PRO - CSP (Connectivity provider)	Driver (Data receiver)
IVS	PRO - SP (Service Provider)	Driver (End user)	OEM (In Vehicle Device manufacturer) , PRO - UEP (After Market Device manufacturer)	

Table 6: Participant networks and their actors of business model cube IVS (Model I: ITS-G5)

The next dimension of the business model cube is the value proposition. In this part, the purpose is to identify the roles, between which a value proposition is exchanged. As in the previous dimension of the business model cube, this is also a tabular representation of the value propositions as represented in the business ecosystem map in Figure 9, that are automatically generated through the linkage between the model and this ecosystem map. In addition, the values that result from these value propositions are made visible. We shall briefly discuss these value propositions and the values they deliver.

In the first row of Table 7, the *PRO-RA&O* in the role of *road operator* provides *analyzed data* to the *PRO-SP* in the role of *analyzed data receiver*. This value proposition has an *analyzed data cost* as a value to measure its service. This cost is measurable and can be expressed in euro/year. In exchange, the service provider provides *analyzed data business* to the public road operator. He makes sure that the data provided is being used, which in its place contributes to the necessity of the analyzed data that the road authority & operator provides. It basically means that it ensures the survival of the PRO-RA&O by providing it with ‘work’. The service provider provides applicability to the devices that the user equipment provider and the original equipment manufacturer fabricate. Without the data driven service provided to the end-user, their devices are useless. In exchange, both device manufacturers provide *visibility on the end-user device* to the service delivered by the service provider. The service provider requires connectivity to provide this service, which is taken care of by the communication service provider. He ensures connectivity to the database of the service provider, *connectivity database*. This connectivity has a cost named *connectivity database cost*, which is dependent on the percentage of coverage by the connectivity and is measured in euro/year. In exchange he provides the communication service provider with connectivity business. If these were separate companies the values that are delivered include would include the payment from the service provider to the communication service provider. However, since these instances are controlled by the government, their compensation is determined by a separate entity. Therefore this is not mentioned in the value column in Table 7. The service provider also provides the *data-driven service* to the driver with values such as the *adjusted speed limit*, *road surface warnings* etc. in exchange for this service they require a *yearly provision fee*. The data-driven business that the driver provides to the service provider contains the *customer base* that makes use of the service, dependent on the % of penetration, and the *PRO app & website cost.*

Value Proposition	From (Role)	To (Role)	Values
Analyzed data	PRO - RA&O (Road operator ***(Partner)***)	PRO - SP (Analyzed data receiver ***(Business)***)	Analyzed data cost 1.10 million euro/year -> Total data cost 16.10 million euro/year (Data result)
Analyzed data business	PRO - RA&O (Road operator ***(Partner)***)	PRO - SP (Analyzed data receiver ***(Business)***)	
Applicability (3)	PRO - SP (Service Provider ***(Business)***)	OEM (In Vehicle Device manufacturer ***(Partner)***)	
Applicability (4)	PRO - SP (Service Provider ***(Business)***)	PRO - UEP (After Market Device manufacturer ***(Partner)***)	
Connectivity business	PRO - SP (Data transmittor ***(Business)***)	PRO - CSP (Connectivity provider ***(Partner)***)	
Connectivity database	PRO - CSP (Connectivity provider ***(Partner)***)	PRO - SP (Data transmittor ***(Business)***)	Connectivity database cost 1.10 million euro/year -> Connectivity database cost 4 (x% coverage) 1.10 million euro/year Connectivity database cost 4 (x% coverage) 1.10 million euro/year -> Connectivity cost (x% coverage) 2.30 million euro/year (ITS - G5 result)
Data driven service	PRO - SP (Service Provider ***(Business)***)	Driver (End user ***(Customer)***)	Adjusted speed limit Road surface warnings Weather conditions Yearly service provision fee 60.00 euro/year -> Data driven service revenues 300.00 million euro/year (IVS result)
Data driven service business	Driver (End user ***(Customer)***)	PRO - SP (Service Provider ***(Business)***)	Customer base (100% penetration) 10.00 million drivers -> Customer base (x% penetration) 5.00 million drivers Customer base (x% penetration) 5.00 million drivers -> Data driven service revenues 300.00 million euro/year (IVS result) PRO app & website cost 0.10 million euro/year -> Data driven service cost 4 0.10 million euro/year (IVS result)
Visibility on End-User device	OEM (In Vehicle Device manufacturer ***(Partner)***)	PRO - SP (Service Provider ***(Business)***)	
Visibility on End-user device	PRO - UEP (After Market Device manufacturer ***(Partner)***)	PRO - SP (Service Provider ***(Business)***)	

Table 7: Value propositions of business model cube IVS (Model I: ITS-G5)

The last column of Table 7 indicates what values are created by each value proposition, its measurement and to what other value it contributes. The proposition *Analyzed data* has a value of *Analyzed data cost* which measures 1.1 million euro/year and aggregates to the *Total data cost* of 16.1 million euro/year, which is part of the *Data result*. This aggregation can be graphically represented in a value aggregation view which is further discussed in section 3.2.2.3. In addition to the above, the VMP provides the option to add satisfaction values and intervals in order to indicate how content the recipient of the value is.

The business ecosystem map (Figure 9) also allows you to view these values, and directly allows you to see the difference of these values over different phases or alternatives in a graph, table or radar view as illustrated in Figure 11 and Figure 12.

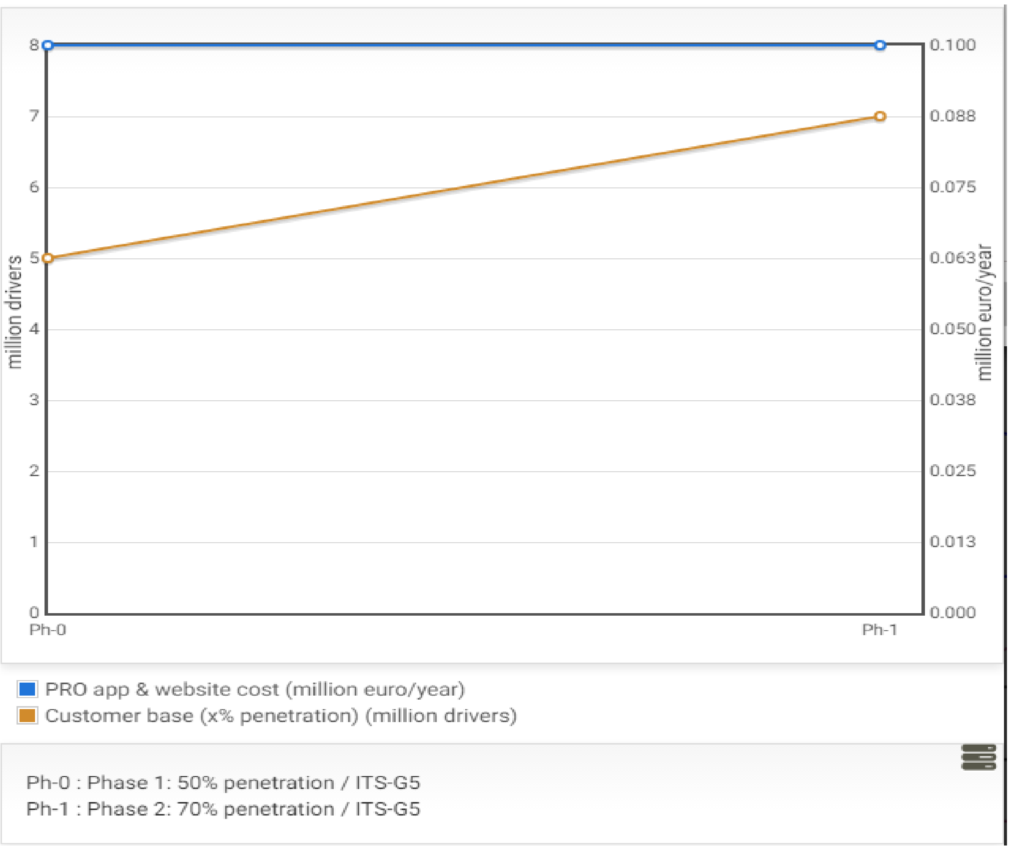

Figure 11: Evolution of the customer base and the PRO app & website cost over the two phases.

The yearly service provision fee stays constant over the phases (as it is not influenced by the change in penetration), while the customer base increases.

In Figure 12 we see a comparison between the market share and the device sales of the original equipment manufacturer for the two alternatives. In the Cellular alternative, he only has a 33.33% market share, since there are three distributers of devices among who this market share is distributed equally. In the ITS-G5 model, he possesses 50% market share and consequently has a higher sales level.

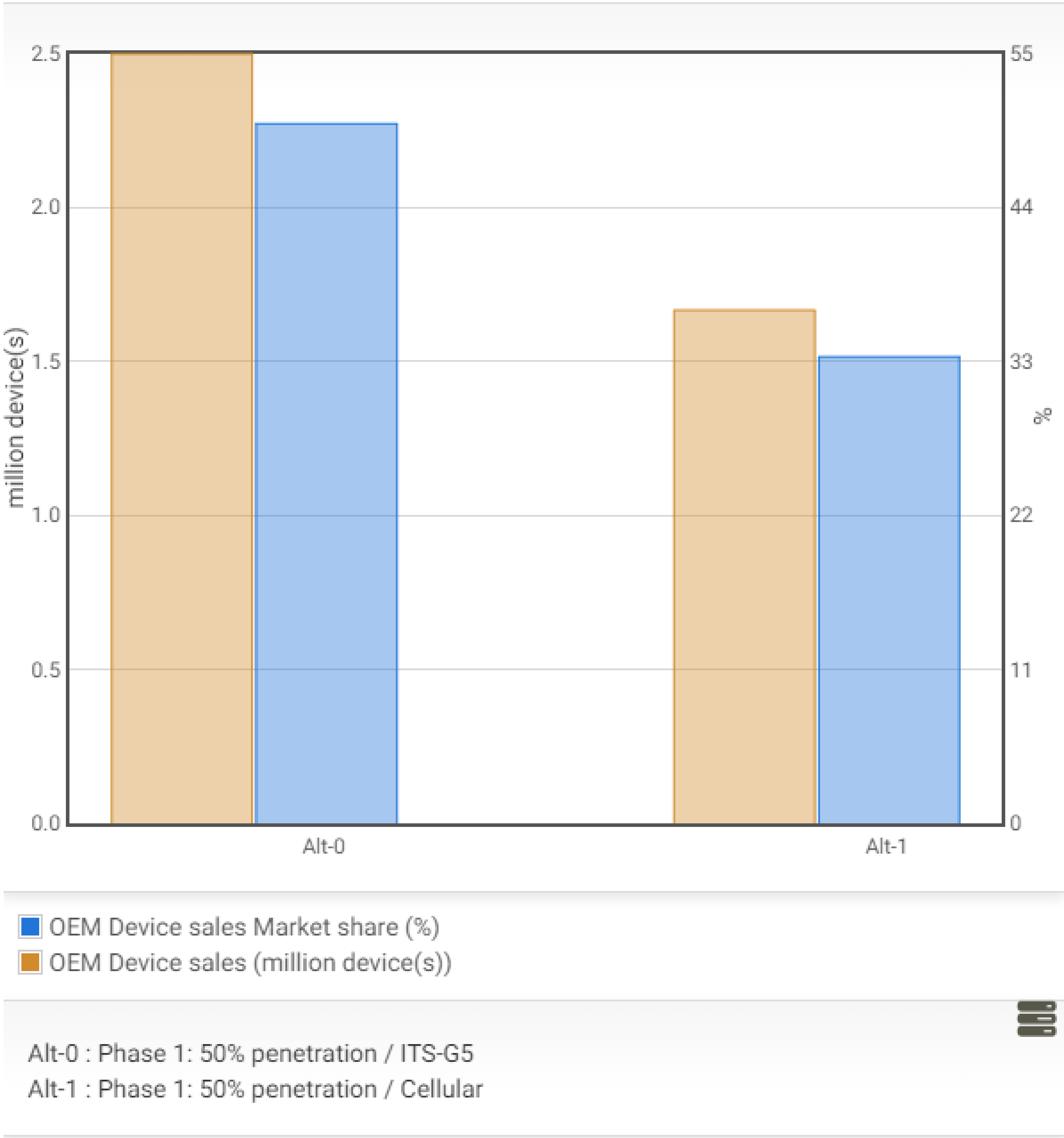

Figure 12: Comparison of the sales and market share of the OEM over Model I: ITS-G5 and Model II: Cellular.

The next dimension we address is called ‘My proposition’. This is the proposition that is captured by the business itself. This proposition can be measured by values such as ‘profit’ or other aggregated values from value propositions or activities such as discussed above. The proposition provided is the *IVS result*. These propositions often end with ‘result’ to indicate that this is the value proposition of the business model towards the business (VDMbee, 2016). The aggregated values that are provided are the *data-driven service* *cost* and the *data-driven service revenues*. The data-driven service cost is aggregated from the connectivity database cost and the analyzed data cost from Table 7. The *data-driven service revenues* is the product of the yearly service provision fees and the customer base. We have not included profit, the reason is that the public road operator is a governmental organization that focuses on other values than purely those of monetary nature, such as environmental sustainability and other societal benefits.

My Proposition	From (Role)	Values
IVS result	Service Provider	Data driven service cost 4 0.10 million euro/year -> Cost to government 243.53 million euro (C-ITS (new)) Data driven service revenues 300.00 million euro/year -> Revenue for government 575.00 million euro (C-ITS (new))

Table 8: My proposition of IVS (Model I: ITS-G5)

Activities (i.e., dimension 4 of the business model cube) need to be executed to fulfill a value proposition (as seen in the first column of Table 9). By performing an activity, the business either creates values or contributes to values, which are already created by the value proposition itself. For example, by receiving the data-driven service business from the customer, the service provider is confronted with a cost that is related to the development and maintenance of the app and website. Therefore the activity *Provide app & website* activity, in order to pursue the value proposition of *Data driven service business*, creates a new value that is called *PRO app & website cost*. This will contribute to the *data-driven service cost* depicted in Table 8.

Pursued	Participant (Role)	Activities	Values
Data driven service	PRO - SP (Service Provider ***(Business)***)	Display relevant traffic information and messages	Customer satisfaction (Display relevant traffic information and messages)
Data driven service business	PRO - SP (Service Provider ***(Business)***)	Provide app & website	PRO app & website cost 0.10 million euro/year (Provide app & website) -> PRO app & website cost 0.10 million euro/year (Data driven service business)

Table 9: Activities of business model IVS (Model I: IT-G5)

To perform these activities, certain competencies are required (i.e., the fifth dimension of the business model cube). VMP distinguishes between two types of competencies: resources and capabilities. To provide the app and website, the public road operator requires the app or website domain name, but also the know-how about how to make a user-friendly interface for the driver. This will facilitate the ease-of-use of the app or website for all drivers, regardless of their technological capabilities.

Activity	My Business (Role)	Competencies
Provide app & website	PRO - SP (Service Provider *(Business)*)	Domain name , Infrastructure , Interface know-how , Legal authority , Qualified personnel

Table 10: Competencies

The last dimension of the business model cube is an enumeration of all values that are used throughout the other five dimensions. Consequently, an overview of all values for the IVS business model cube can be found in 1Appendix 9.

3.2.2.3 Measuring value

The values that were defined in the previous activity are most useful if they can be measured. Changing the measure of the values is also a way to model different scenarios. For the IVS case, the information about costs and other measurable values are scarce. Consequently, a lot of the measurements are based on assumptions.

In the VMP the measurements of values implemented can be aggregated. This means that they are the outcome of a mathematical operations of multiple values. The strategy map, as discussed in 3.2.1.4, provides a first insight in the links between some global values. When implementing values in VMP, we can split these values in smaller parts in order to cover every aspect of these values. For example in Table 7, the *Analyzed data cost* (1.1 million euro/year) is aggregated from the *Hardware & Software cost* (1 million euro/year) and the *Algorithms development cost* (0.1 million euro/year) and is aggregated to the *Total data cost* (16.1 million euro/year). This *Total data cost* contributes to the *Low cost to government*, as represented in section the strategy map in section 3.2.1.4 Figure 10 and in in the value aggregation view in 1Appendix 10 Figure 27.

When having a large model, it sometimes becomes hard to maintain a global overview of all these value aggregations. The VMP provides the option to quickly create a ‘value aggregation’ view, which graphically represents how values are aggregated. In this particular example this leads to the view as presented in Figure 13, which allows you to quickly see what constitutes each value and to what values it contributes. It is possible to extend this even further and include even more values. Another example of this view is added in 1Appendix 10, Figure 27 and Figure 28.

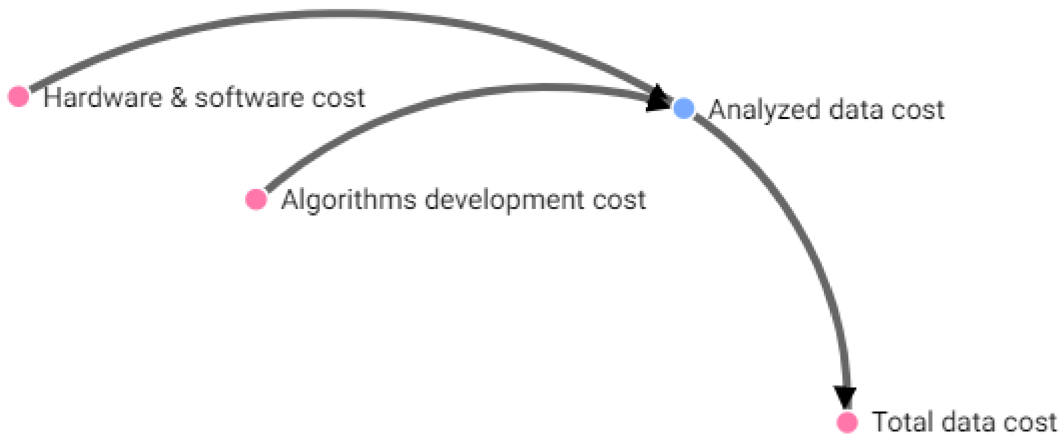

Figure 13: Value aggregation view

The value management platform allows you to monitor the progress of the values of your strategic initiative during different phases. This can happen separately for Plan values or Business model values, or aggregated in a dashboard, which will be discussed in 3.2.3.

3.2.3 Adopt

To obtain approval for the execution by stakeholders, presenting the feasibility of your plan by evaluating what-if scenarios and possible alternatives is a must. VDMbee suggests a structured approach to realize this, consisting of three steps: present, decide, and initiate.

3.1.1.1 Present

The VMP provides three different visualizations: graph, tabular or radar. These representations can be used to show plan values and business model values separately for a quick review, or together in the dashboard for a more complete overview. It is possible to represent these values over different phases, alternatives or both. This makes it easy to view the impact of certain decisions in each alternative, or how certain values are assumed to change during different phases.

First of all the presentation should consist of clarifying the transition of the plan values from phase 0 to phase 1, as shown in Table 11. The 20% increase in *Penetration* clearly results in a higher cost but also revenue for the government. The increase in *Sustainability* is higher due to the more efficient traffic flow achieved by a higher penetration. In 1Appendix 11 the two other representations of the same values are added. Radar view is useful when there are more than two different scales, as is the case in our example (The scales are: 'Ton COx', 'million euro', '%' and 'million drivers' and are represented between brackets in Table 11).

Values	Ph-0	Ph-1
Cost to government (million euro)	243.53	333.53
Coverage (%)	100	100
Licensed Vehicles Netherlands (million drivers)	10	10
OEM provider market share (%)	50	50
PRO provider market share (%)	50	50
Penetration (%)	50	70
Revenue for government (million euro)	575	805
Sustainability (Reduction COx) (Ton COx)	214	299.6

Table 11: Evolution of measurable plan values between Ph-0 (50% penetration) and Ph-1 (70% penetration)

Secondly, the presentation should also compare the plan values of two different alternatives, as represented Table 12. The differences between both alternatives results in the absence of measurements of certain values. In Alt-1 (Model II: Cellular), it is considered that there are three device providers who each have an equal market share in the In Vehicle Signage market (consisting of devices and the service delivery). The PRO does not sell devices nor provide any data driven service towards the end user and has thus no revenues from both these services and a zero market share.

Values	Alt-0	Alt-1
Cost to government (million euro)	243.53	16.13
Coverage (%)	100	100
Licensed Vehicles Netherlands (million drivers)	10	10
Mobile phone provider market share (%)		33.34
OEM provider market share (%)	50	33.33
PND provider market share (%)		33.33
PRO provider market share (%)	50	
Penetration (%)	50	50
Revenue for government (million euro)	575	
Sustainability (Reduction COx) (Ton COx)	214	214

Table 12: Comparison of plan values between Alt-0 (Model I: ITS-G5) and Alt-1 (Model II: Cellular)

The cost to the government is a lot lower in Alt-0 (Model II: Cellular) than in Alt-1 (Model I: ITS-G5). This is due to the fact that certain costs, such as the connectivity cost, the production of the devices, nor the delivery of data driven service (with a 50% market share), are no longer part of the cost to the government, but are 'outsourced' to private companies.

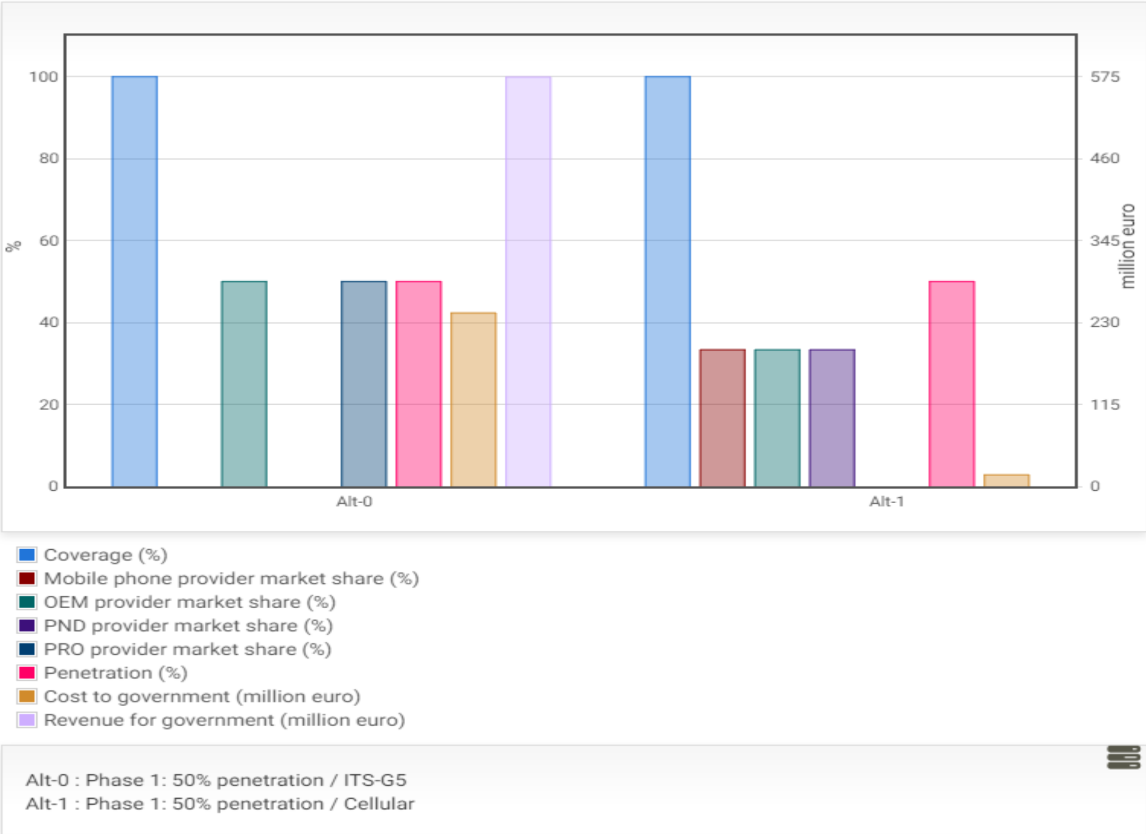

Figure 14: Bar chart in VMP (Alt-0 = Model I: ITS-G5, Alt-1 = Model II: Cellular)

In Figure 14 the first alternative (Alt-0) the market share is assumed to be equally distributed among the PRO and the OEM. In the second alternative (Alt-1) the PRO does not sell devices and thus has no more market share. Instead the market share is equally distributed among 3 other players in the market, who each provide their own devices. The cost of the government is substantially lower since everything but the data processing and analysis cost, as well as the division of standards and regulations, is being delivered by private companies.

The views as presented above allow for a comparison and discussion between alternatives and evolution of values through phases separately. It is however also possible to combine both of these approaches in a dashboard. This dashboard allows the business model expert to select values from which other users can choose (in order to prevent less tech savvy users to be saturated by the overload of data). This permits the expert to choose the most relevant values and permit other users to easily construct different comparisons between them. In the table below we have made a comparison between values that can influence the government on making a decision.

Values	Ph-0	Ph-1	Ph-2
% reduction of COx per km (%)	2	2	2
Cost to government (million euro)	16.13	243.53	333.53
Coverage (%)	100	100	100
Mobile phone provider Total profit (million euro)	166.7		
Mobile provider market share (%)	33.34		
OEM provider market share (%)	33.33	50	50
OEM total profit (million euro)	33.33	50	70
PND provider market share (%)	33.33		
PND total profit (million euro)	33.33		
Penetration (%)	50	50	70
Raw data cost (million euro/year)	15	15	15
Raw data cost (x% coverage) (million euro/year)	15	15	15
Revenue for government (million euro)		575	805
Sustainability (Reduction COx) (Ton COx)	214	214	299.6
Total in-car device profit (million euro)	16.67	25	35

Ph-0 : Phase 1: 50% penetration / Cellular
Ph-1 : Phase 1: 50% penetration / ITS-G5
Ph-2 : Phase 2: 70% penetration / ITS-G5

Table 13: Comparison of values between the alternatives and phases.

The VMP also allows you to easily make reports with the ecosystem map and business model canvas and other discovery approaches attached. It is also possible to attach other sources, such as PowerPoints and images to facilitate well-founded discussions and ensure that no important values are overlooked.

3.1.1.2 Decide & initiate

The above step should provide stakeholders with enough insights to allow an efficient discussion. This discussion is often based on the importance and priority of certain values. It is thus of crucial importance that all possible scenarios are covered in the previous step in order for the organization to quickly make decisions, which will increase responsiveness of these organizations to changing market circumstances.

We shall no further elaborate on the decision and initiation step, since this case is used solely as a theoretical illustration for the underlying research question, and because of the scope of the research, only the basics of the IVS case are covered, and not enough realistic details are used because of the unavailability of information in order to permit policy makers to make a well-founded discussion or evaluation about implementation.

4. Comparison

In this section, we compare the DAMIAN and VMP approaches on different levels. We will start by providing a high-level comparison in section 4.1 before going into more detail in section 4.2. In this section the meta-model is compared, after which we discuss the modelling method and finish with the tool support for each of the methods.

4.1 High-level comparison

There is a clear difference between the scope of both approaches. The main purpose of DAMIAN is to provide a neutral foundation for efficient discussion-making for policy makers and regulators, while VMP is primarily relevant if a business wants to prototype and explore what strategic initiatives and directions are best for implementation in case of a potential transformation. VMP aims to support the transformation of a business to keep up with its competitive and dynamic environment, while DAMIAN means to support policy and regulation design. The difference in objective is reflected in the target audiences. This, together with other differences are put in Table 14.

	DAMIAN	VMP
Origin	Developed by TNO.	Based on Value modeling, more specifically the VDML metamodel, which in turn results from a unification of value modeling and business model representation techniques and conceptual frameworks.
Main Objective	Create a neutral and shared foundation for discussions about policy and regulations in converging markets.	Managing a phased approach to business transformation. Evaluating alternative ideas before real strategy implementation.
Aim	Create a clear view of the interdependencies between organizations in the web and determine how regulation affects the interdependencies and conditions in which organizations offer their services	Create a clear view of the organization for all stakeholders involved to make a rational decision about the future direction. Fill the gap between strategic planning and business operations.
Core activity	Visualization of service delivery routes, organizations, assets and regulation in the value web.	Identifying and modelling the different enterprises and their values in accordance with possible strategic initiatives.
Approach	Stepwise approach to identify the organizations, assets and regulation in the value web, supported by a graphical modeling tool to aid the final steps of the process.	Stepwise approach with different modeling tools (business model canvas, business ecosystem map…) implemented in a single platform to support every step of the process.
Values	Mainly virtual & digital assets. Intangible value exchange.	Physical/ digital and/or virtual assets i.e. tangible, non-tangible, financial and non-financial values.

	DAMIAN	VMP
Target Audience	Policy makers & regulators. Also other stakeholders such as content providers, device makers and consumer interest groups can benefit from this approach.	Managerial audiences, business people-executives, business architects and analysts. These functions are targeted in both the private and the public sector.
Value exchange view	Based on the value web view in which similar services can follow multiple parallel routes between creation and consumption.	A global value exchange view is possible through the use of the business ecosystem map, which allows the user to zoom in on aspects in order to present different levels of detail.
Viewpoint	Global viewpoint, structured graphical overview of the whole value web and interactions between the different participants.	Viewpoints from the perspective of different actors, with different levels of detail possible, to efficiently address the concerns of different stakeholders.
Level of granularity	Low degree of granularity with minimal detail about the value exchanges.	High level of granularity with detailed view of the value exchanges possible, whilst also providing a global and low level of granularity overview that can be presented to a broader stakeholder audience.
Field of application	Digital services	Services (both digital and non-digital), manufacturing…

Table 14: comparison between DAMIAN and VMP

The approach in which both methods address their core activity seems very similar. They are both stepwise and start with general exploring of the ecosystem. The biggest difference is the support by a tool that each of the methods has. While VMP is a complete tool with overall support throughout the whole process, the DAMIAN tool only provides support while making the service delivery canvas. The value streams in DAMIAN are mainly virtual and digital. This is because it focusses on the regulation in the value web of emerging digital services that have the potential to shift the balance of power in this value web. The value management platform can support both tangible and intangible value streams. Another difference that stems from the objective of each of the methods is the viewpoint that each of the methods provide over the models. In DAMIAN, this is an overall viewpoint, in order to enable all policy makers and regulators to be on the same page and facilitate discussion. The VMP supports multiple viewpoints in order to allow each of the different stakeholders to gain an understanding of that part in model which is relevant for their field of expertise and consider the (in)feasibility of certain assumptions.

The main objective of the VMP (managing a phased approach) also implies the discussion of alternatives. This discussion is an important aspect that recurs both in DAMIAN and the VMP, which is facilitated by the views of each method that allows for the stakeholders to on the same page.

4.2 Detailed comparison

4.2.1 Metamodel

Figure 15 represents the metamodel by which concepts of VDML are linked in the VMP. Remark that some of the concepts do not have the same as association as the metamodel of VDML as defined by the Object Management Group (2015). For instance, the *Competence* class is modeled here as a superclass of both resources and capabilities. In VDML however, not every resource can be considered a competence. VDMbee did consider implementing this this. If they had pursued this, a distinction would be made between competence and non-competence resources. VDMbee did not do this because in the VMP as currently available, modelers are not expected to insert non-competence resources. These competences are considered to be part of the value proposition received by the party that possesses the competence. The VMP does allow the addition of this extension if this would be required in the future, since adding a parent generalization in the metamodel is not hard.

When looking at the metamodels of the VMP (Figure 15) and DAMIAN (Figure 16), it is easily observable that there are some recurring classes. Both methods need the identification of participants, roles and the activities that each of the participants performs in its roles, as well as the assets (or values) that they own or need to acquire from other participants to deliver their services. However these are not related in the same way. For example, activities in DAMIAN are a superclass of assets, which are digital and owned by participants. Activities in the VMP contribute to assets or values in the value stream, instead of being enabled by assets. If we see a certain value that is being created, it requires one or more underlying activities that create this. Although activities appear in both methods, they clearly have a different relation compared to the other classes.

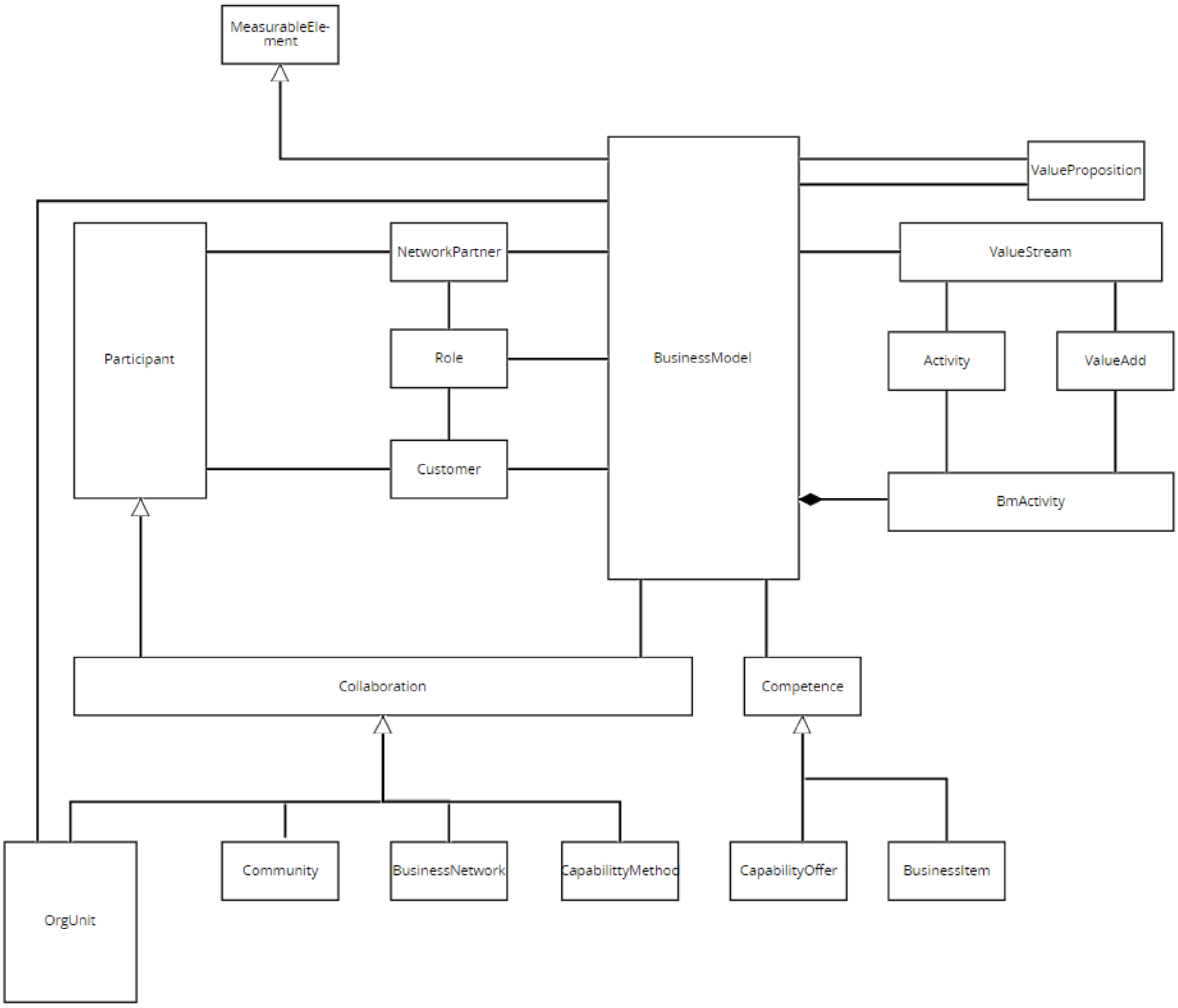

Figure 15: VMP metamodel.

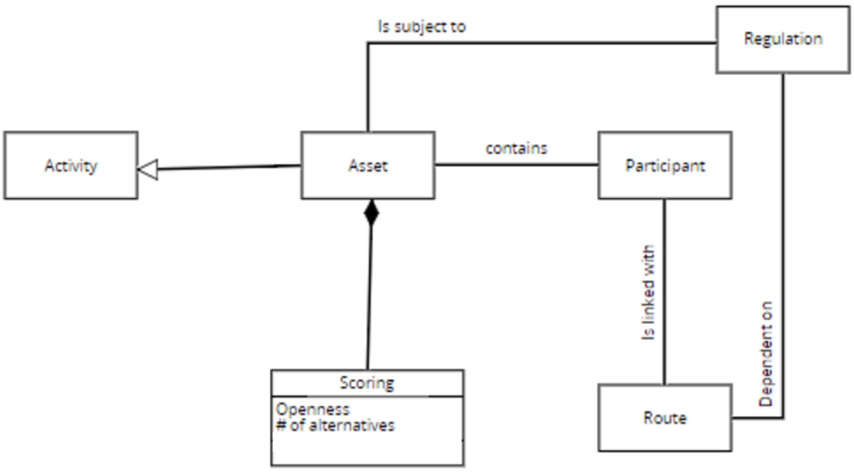

Figure 16: Service delivery canvas (DAMIAN) metamodel.

There are however some overlaps between both metamodels that can be exploited when going from a DAMIAN service delivery canvas to the VMP tool. One of these is that the assets in the DAMIAN canvas can be used to identify the different roles that participants have in the VMP. An asset class in DAMIAN contains participants. These asset classes give an indication of what kind of contribution each participant has to the final service that is provided to the end-user. Each of the participants has a role, in which they perform an activity in the VMP. Often the role it has refers to the activity he performs. In our example we can link *Service provider* to *App & website*, since this is the service he provides towards the End-user. We can also see that there will be need for a data aggregator to provide the *aggregation* asset. This is depicted in Figure 17.

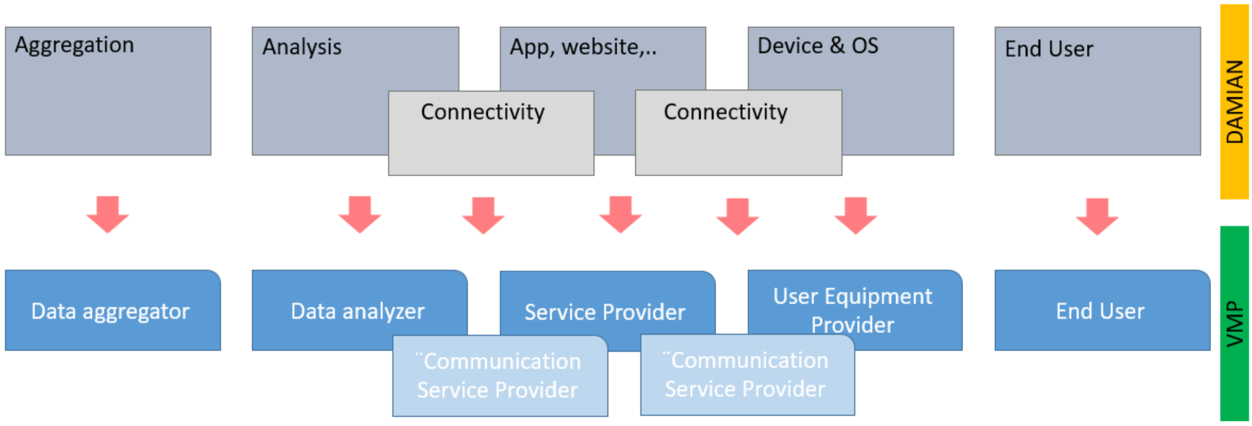

Figure 17: Roles in the VMP derived from the asset classes from DAMIAN

This linkage can prove very useful to avoid double work if one already has performed DAMIAN or VMP.

From the service delivery canvas in Figure 5, we can see that the *Device & OS* delivers the final service. Note here that according to the VDML specification 1.0 ((Object Management Group, 2015), an actor is allowed to be human (a Person) or non-human (e.g. a software agent or machine). The device can thus be considered a participant who operates within a role. However, since the case discusses the presence of user equipment providers who differ across alternatives, the device was not treated as a participant but as a value proposition, delivered by different user equipment providers (which are modeled as participants). In this manner the device becomes part of the value proposition that is delivered by the business model cubes of these providers. We model the participants who provide this device. But now the sequence as shown in the service delivery canvas in Figure 5 is no longer correct. The service provider does not provide the data-driven service to the user equipment provider, but to the device, which is in possession of the end-user. We therefore need a separate value flow than the one in the business ecosystem map to model the (tangible) device flow, and the (intangible) service flow towards the end-user as shown in Figure 18.

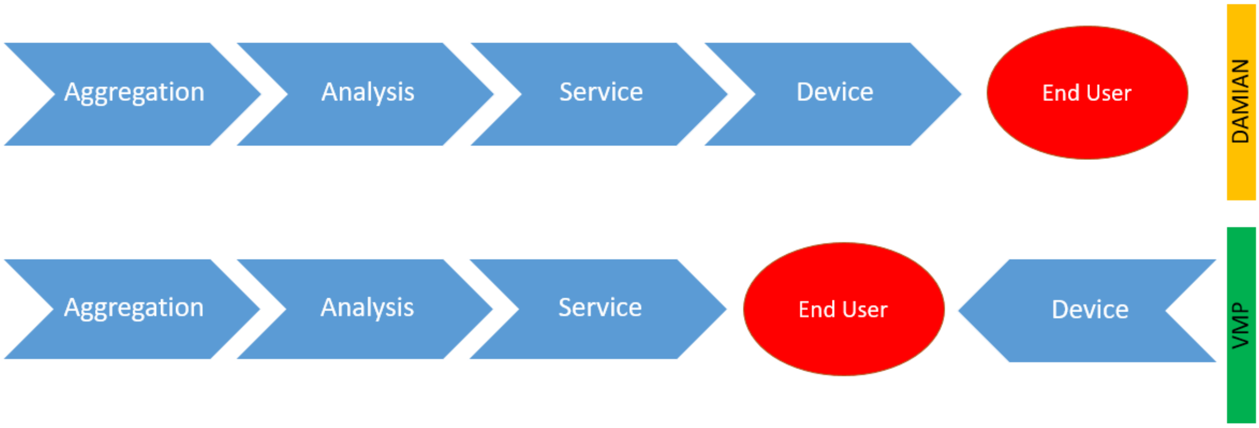

Figure 18: Value flow DAMIAN vs VMP applied to the case

The use of the business models of the user equipment providers has the additional benefit that impact of different types of regulations can be assessed on the business models of these providers. For example if there need to be added an accident notification option, that the extra cost incurred for device manufacturers would not diminish demand (and thus penetration, which is a value that is important for the government) as a result from higher prices.

4.2.2 Modeling method

Besides the tools' metamodel of both approaches, it is also useful to identify the differences and overlaps in the modeling method in order to see if either method can learn from one another or if some steps could be re-used if a unified approach of both would be created.

As mentioned in section 4.2.1, both methods require the identification of all participants, their role and the part they play in the delivery of the service. In DAMIAN, this leads to an integrated view of the interdependencies and the possible routes that can be followed throughout these organizations to achieve the delivery of a certain service. This is graphically represented in the service delivery canvas. In the VMP this leads to the creation of a dynamic model (in the sense that it can easily be adjusted to changing conditions by adapting measurements or the structure, or that it can consider multiple alternatives and/or phases simultaneously to clearly identify differences on values that are considered important) that helps you and your stakeholders to be effective in decision making and control about the future direction of the company. Like the service delivery canvas in DAMIAN, there are also visual representations in the VMP, though of a different nature. The business ecosystem map leans most towards the service delivery canvas. In contrast to the DAMIAN method, this graphical notation is created in one of the earlier stages, during the more exploratory phase of the model creation. Nevertheless, it continues to play an important role in the later stages, as it is often used as a guide during the whole process and can be re-evaluated in subsequent phases if necessary. The service delivery canvas aids the users to conduct a discussion about policy and regulation by providing an overall view depicting all relevant routes. The business ecosystem map however, which is an extension of the VMP, is a means to gain first insights in the different participants and the business models that will be modeled in step 2: Prototype. The use of the business ecosystem map is a way to facilitate this step, not only due to the fact that many elements that are mentioned in the map recur in the prototype phase, but also since the VMP allows for linkage between this canvas and the business models and participant networks in the prototyping phase. If the mapping is done correctly, the main structure of the model in the prototype step is already automatically generated.

Since there is an overlap in the participants between the business ecosystem map of the VMP and the service delivery canvas of DAMIAN, the canvas can be used as an additional facilitating tool when identifying the participants and possibly when proceeding to the prototyping step in the VMP. For the prototyping step, it is required to know which of the participants require a business model in the business ecosystem map. The different participants as found in the service delivery canvas can give a first indication of the businesses that own a business model (Figure 19). As stated in 3.2.1.3, the conditions for deciding whether a participant owns a business model depends on whether it makes sense to see the impact of certain changes on its values. This aspect is decided by the user, which in the case of DAMIAN is the government. If the government wishes to test regulations that affect all actors in the service delivery canvas, then all actors will require a business model. If it was required, even the driver could own a business model, a special kind that would be. If there are however actors that are not influenced by the introduction of certain regulation, they can be modeled as roles or individuals, as seen in Figure 26 of 1Appendix 4. After these participants and business model cubes are identified it is possible to go into further detail and describe other dimensions of the business model cube of each of these participants.

There is thus a complementarity between the actors as described in the service delivery canvas in DAMIAN, and the participants that own a business model cube in the business ecosystem map in the VMP.

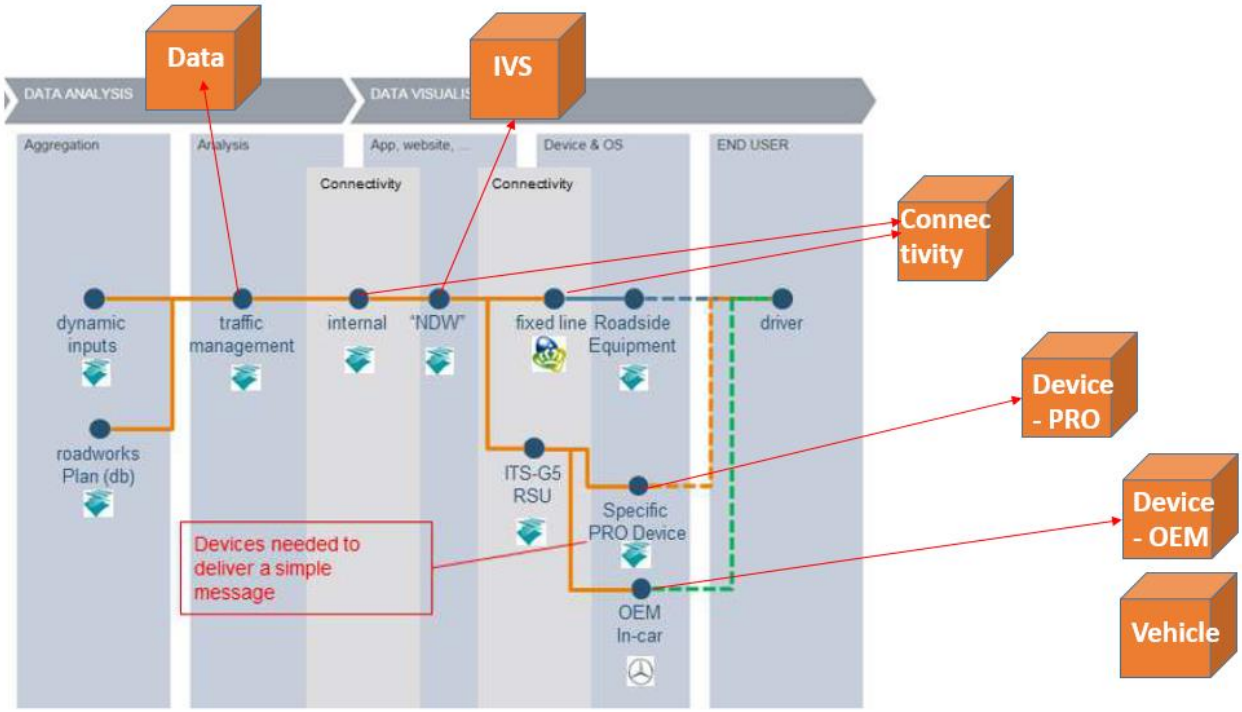

Figure 19: Links between business model cubes in the VMP and participants in the service deliver canvas

The link between the participants in DAMIAN and these in VMP is not always a 1:1 relationship. In Figure 19 the in-car device is provided by the OEM, but the OEM does not deliver this device directly to the End-user. This is done by the car manufacturer, who assembles the device in the vehicle on request of the customer. To take into consideration this tangible flow in the VMP a new business model, 'Vehicle' that is owned by a new participant, the car manufacturer (which is not presented in the service delivery canvas) was created. This is not represented in DAMIAN since this is a tangible value flow of a vehicle towards the customer, and DAMIAN only focuses on intangible flows.

The use of alternatives is another concept that recurs in both methods. In IVS, we have considered three alternatives of communication service provision. The ITS-G5 scenario, the 4G/5G scenario and the hybrid case. In DAMIAN, these alternatives are modelled in different service delivery canvases. This is not a very hard task, since once the empty service delivery canvas and its assets are defined, it is just a matter of changing the different participants and drawing the routes to change the content. In the VMP this is also an easy task. It is possible to create alternatives for plans that deviate from the base alternative. This makes sure that you don't have to re-enter the whole business model cubes for businesses who are similar, and also to make minor modifications in certain values, for example expected sales level or expected market growth to model different scenarios or add new participants.

Next, we focus on the level of abstraction in both methods, which is a direct consequence of their main objectives. The VMP maps (the transformation of) a single business and what the impact on the values is of the considered strategic alternatives. A lot of detail is required about each business that is modelled to allow for a thorough comparison of these alternatives. This allows the stakeholders to make a well supported decision about which alternative to pursue. In the DAMIAN method, the level of abstraction is a lot higher in such a way that it is not modelled what the impact on the values of the different organizations are, if there was to be followed another route towards the end-user. The level of detail is restricted to that which is required to ensure an efficient discussion about policy and regulation, without any measurable values. However it might be useful to see what the impact of regulation is on the bottom line of the participant to which it applies. This not modelled in DAMIAN, but can be modelled in the VMP. This can be done for example by adding the business model of the Government, who operates in a participant network, let's name it 'Regulation', and provides value propositions towards its customers such as the public road operator, the device provider(s), but also the driver with for example traffic regulations. Since VDML supports both tangible as intangible value flows, it is possible to model the regulation as a value flow, which has consequences on values of the business model cube of the organization to which these regulations apply. Another option would be to make accurate estimates of the impact that certain regulations have and create new alternatives based on these estimates. A short example of this is provided in section 4.3.2.

We know that the main idea behind the DAMIAN approach is that there are several routes through which the end-user can be provided with a similar service, though subject to different regulations. In the Value Management Platform it is also possible to model different routes. This can be done by adding business models of those participants who offer the parallel routing in each of the alternatives (ITS-G5, 4G/5G or hybrid). In this way it is possible to model these parallel value propositions, as shown in Figure 20. This approach can also be used to model the presence of competitors in the market, if enough information about their cost structure is known and if it is required to take its point of view. If not these participants can also be modeled as roles or individuals.

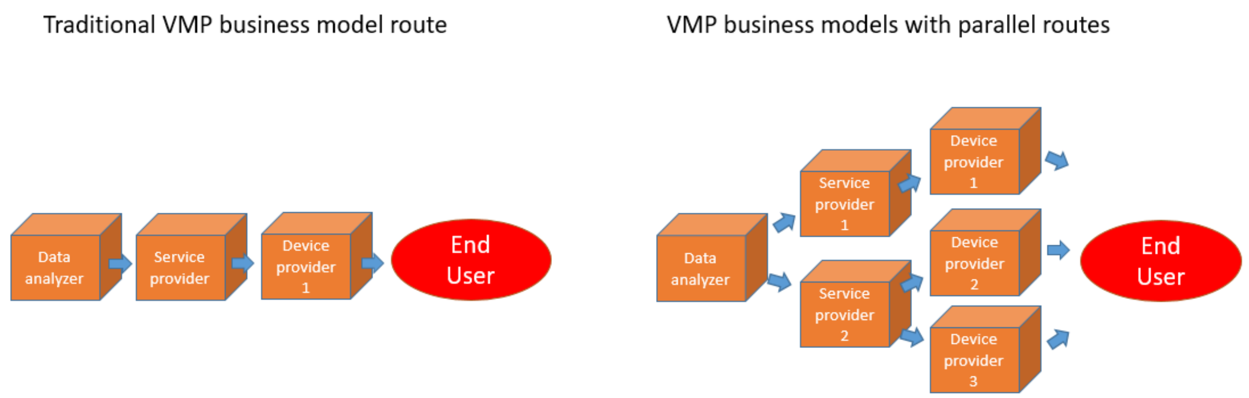

Figure 20: VMP single versus parallel routes through business models, applied to the IVS case.

The blue arrows of Figure 20 indicate the direction of the main value flows, while the squares represent the business model cubes of the VMP. In the left part of the figure, there is a single service provider who provides the data-driven service which is compatible to a single device. Consider for example *service provider 1* to be the public road operator. It is not improbable that there are multiple service providers who offer their service in parallel to that of the road operator, (if this is authorized by law) nor that there are several device providers. Take for example that *service provider 2* is a mobile network operator who also provides this service, *device provider 2* to be an after-market device provider, and *device provider 3* to be the original equipment manufacturer who provides a device that is installed in the vehicle at the car manufacturer’s plant. There are thus several devices and routes through which the end-user can receive a similar service. The device providers can be considered participants who each capture a part of the market, and are thus direct competitors. It is thus possible to model the parallel routes in the VMP as is seen in the service delivery canvas of DAMIAN, which can also be visually represented in the business ecosystem map.

4.2.3 Tool support

Both methods are supported by software tool. In DAMIAN this is a tool that helps the implementation of the service delivery canvas. This tool is still rudimentary (i.e. there is no user guide and the tool is not yet user-friendly) and covers only the essentials of the canvas creation. DAMIAN is applied in many multi-stakeholder workshop settings and has received many positive feedback (Nooren, Koers, Bangma, Berkers, & Boertjes, 2014).

The VMP app is a complete platform that supports all phases from exploration to adaptation. The platform is continuously improved and adjusted to developments in the field of value modeling by VDMbee. The VMP comes with a manual and elaborate descriptions of each concept for those who are less familiar with the value delivery modeling language, or value modeling as a whole. VDMbee provides strategy workshops for business people who face the challenges for which the VMP provides relief. This consists of a three day training which can be delivered onsite or in their Netherlands office.

4.3 Complementary of DAMIAN and VMP

4.3.1 Complementary approach for DAMIAN and VMP.

The complementary use of DAMIAN and VMP could allow users to capture the strengths of the VMP and its underlying VDML language, together with the specific focuses of the DAMIAN approach concerning regulations. It would allow DAMIAN users to more easily generate different alternatives and view their impact, whilst simultaneously allowing the VMP to target governmental audiences and policy makers who have difficulties with inefficient discussions about regulations more explicitly. In this section a unified approach is suggested that allows modelers (who aim to resolve the issues that regulators aim to face with respect to data driven innovations) to reap the full benefits of integrating both approaches and tools.

Figure 21 provides a quick recap of the steps that both methods propose. Some of the steps that DAMIAN proposes can be categorized in phases of the VMP approach.

DAMIAN

- Step 1: Identify trigger
- Step 2: Determine Scope
- Step 3: Identify actors
- Step 4: Draw Routes
- Step 5: Identify assets
- Step 6: Assess assets
- Step 7: Identify regulation
- Step 8: Identify tensions & issues
- Step 9: Discuss
- Step 10: What-if Scenario's

VMP

- Phase 1: Discover
- Phase 2: Prototype
  - Planning
  - Designing
  - Measuring value
- Phase 3: Adopt
  - Present
  - Decide
  - Initiate

Figure 21: Comparison of the DAMIAN and VMP approach

If both methods were used separately, a lot of duplication is performed (for example the identification of actors and assets, which is required in both methods, although differently applied in each of the methods). The stepwise approach that is suggested is shown in the bullet points of Figure 22.

Integrated approach

- Phase 1: Discover
  1) Identify the mission, vision & strategy of the government
  2) Identify trigger
  3) Determine Scope
  4) Idenfity actors
  5) Draw Routes
  6) Identify assets
  7) Assess assets
  8) Identify regulation & plan values
  9) Identify tensions & issues
  10) Business ecosystem map
- Phase 2: Prototype
  1) Planning
  2) Designing
  3) Measuring value
- Phase 3: Adopt
  1) Present & what-if scenario's
  2) Decide & discuss
  3) Initiate

Figure 22: Suggested unified approach of VMP and DAMIAN

The main structure of the integrated approach is the same as the one suggested by the VMP. The reason for this is that this already provides a good backbone for all sorts of business initiatives and that many steps performed by DAMIAN recur in the VMP approach. The Discover phase more explicitly begins with the identification of the mission vision & strategy of the government. This can help with the following step to ensure that the new trigger that is identified is in line with the core values of the government. The following steps are those provided by DAMIAN in order to create the service delivery canvas, which preferably could be implemented in a (new) VMP extension. When identifying the regulation (step 7 of DAMIAN) an additional action is proposed in Figure 22. Not only are the regulations identified, but also the main values on which these regulations have an impact (this will make sure that these values can be easily adjusted when regulators want to see the impact of each of these regulations on the business models of the participants). The service delivery canvas extension in the VMP would allow the user to link this directly to the business ecosystem map to reduce modelling effort. This way participants and (intangible) value propositions that occur in the service delivery canvas are automatically duplicated in step 10 of phase 1. The user can be given the option for which of the participants a business model cube is required. If the regulator wishes to see what impact regulation has on this participant, the answer will most likely be 'yes'. In Phase 2 the models are created and refined with accurate or estimated values and their measurements. Values to which the regulations have an impact that were now identified in step 8 of Phase 1 should be modeled as 'Plan values', whilst more specific values that are impacted by these plan values can be modeled as business model values in each of the participants' business model cube. During step 10 of phase 1, other tools, such as the business model canvas and the strategy map can be created to facilitate consistency throughout the following phase, which is identical to phase 2: Prototype, as suggested by the VMP. The first step of the third phase allows for the government to see the impact of a single regulation under different circumstances, or see the impact of different regulations in the same circumstances. The VMP allows for a thorough analysis of these values in order to allow for well backed decision making. An illustration of this is provided in section 4.3.2.

The main change to the VMP tool itself that is suggested here is the addition of a service delivery canvas extension that can be used during the discovery phase and can be linked to the business ecosystem map. With this addition, the VMP does not lose focus since users can choose whether the service delivery canvas is relevant to take into account for their business transformation or not. In the case of a governmental body that seeks to explore new regulations throughout the value web to maintain a fair balance of power for different participants, this will most likely be used.

4.3.2 Example of complementary use of both methods on IVS.

In this section a short illustration will be made of how the complementarity of both approaches can be exploited; more specifically how the impact of regulations, as identified in the service delivery canvas can be modeled in the VMP by the use of alternatives. This corresponds to phase 3 of Figure 22. Phases 1 and 2 are not repeated here, since these steps are identical to these discussed in earlier sections 2 and 3.

In the service delivery canvas, we can see what types of regulations have an impact on which routes and the participants that are connected by these routes. In the VMP it is possible to adjust certain values to which these regulations apply and automatically see the effect on all participants to which these regulations apply. Consider in the IVS case, alternative 1: ITS-G5. Suppose the government is thinking of adding regulations, as identified by the DAMIAN method in section 2.2.10, in order to increase initial penetration in Phase 1 from 50% to 60%. An option would be to subsidize the OEM and the PRO-UEP in order to reduce prices towards end users. The question the government could have is how this would affect the cost to the government and the profit of the OEM.

Suppose the government estimates that with an initial price of 81 euro for the devices (in comparison to 101 euro now) the desired level of 60% penetration will be achieved. The government subsidizes 20 euro per device sold by both parties. Since the models are already complete, this is a very easy task. We briefly discuss the steps required:

1) Create a new alternative in Phase 1 named 'ITS-G5: subsidized'. This results in the duplication of all values and business models from the base alternative (Model I: ITS-G5). So the hardest part of modeling is no longer required here.
2) Since the presence of subsidies was not considered in the base alternative, a new plan value is added named *Subsidy* and equal its value to 20 euro/device (If this value was already considered in the base alternative, but for example equal set to 0 euro/device, then we could simply change the value to 20 euro/device and skip the final step, since values would already be aggregated).
3) Aggregate the new values. In this case; subtract the 'Subsidy per device' value from the 'Device price' of the device providers. Device providers are assumed to sell their devices with a fixed mark-up (Device price = Device cost + mark-up). This value formula becomes 'Device price = Device cost – subsidy + mark-up'. Next create another plan value named 'Total subsidy cost' = penetration *

subsidy * Licensed vehicles Netherlands'. Lastly this cost is added to the *Cost to government*. This value aggregation is presented in Figure 23.

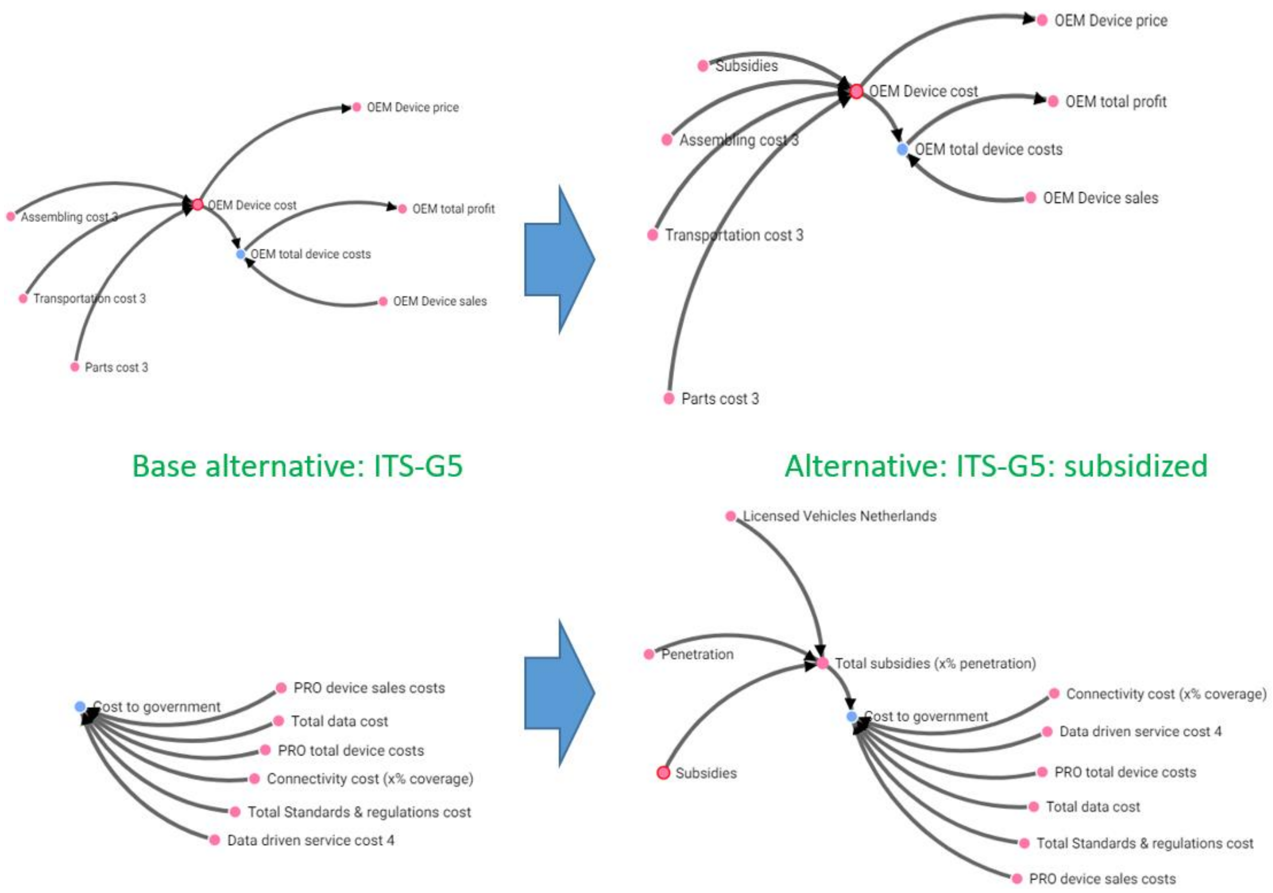

Figure 23: Value aggregation view of the base alternative (left) compared to the new alternative with subsidies (right)

Now we can compare the plan values for both models, present to them to the different stakeholders and let them decide which of the alternatives should prefer adoption. Figure 24 shows that the cost to government increases substantially due to these subsidies, and there is only a small increase in revenues due to the increased penetration which resulted in increased device sales and yearly fees for the data-driven service. There is however a relatively large reduction in COx emissions due to the higher device penetration. It is up to regulators to decide whether this is worth the extra cost incurred. Table and graphical view of these values are added in 1Appendix 15, Figure 33 and Figure 34.

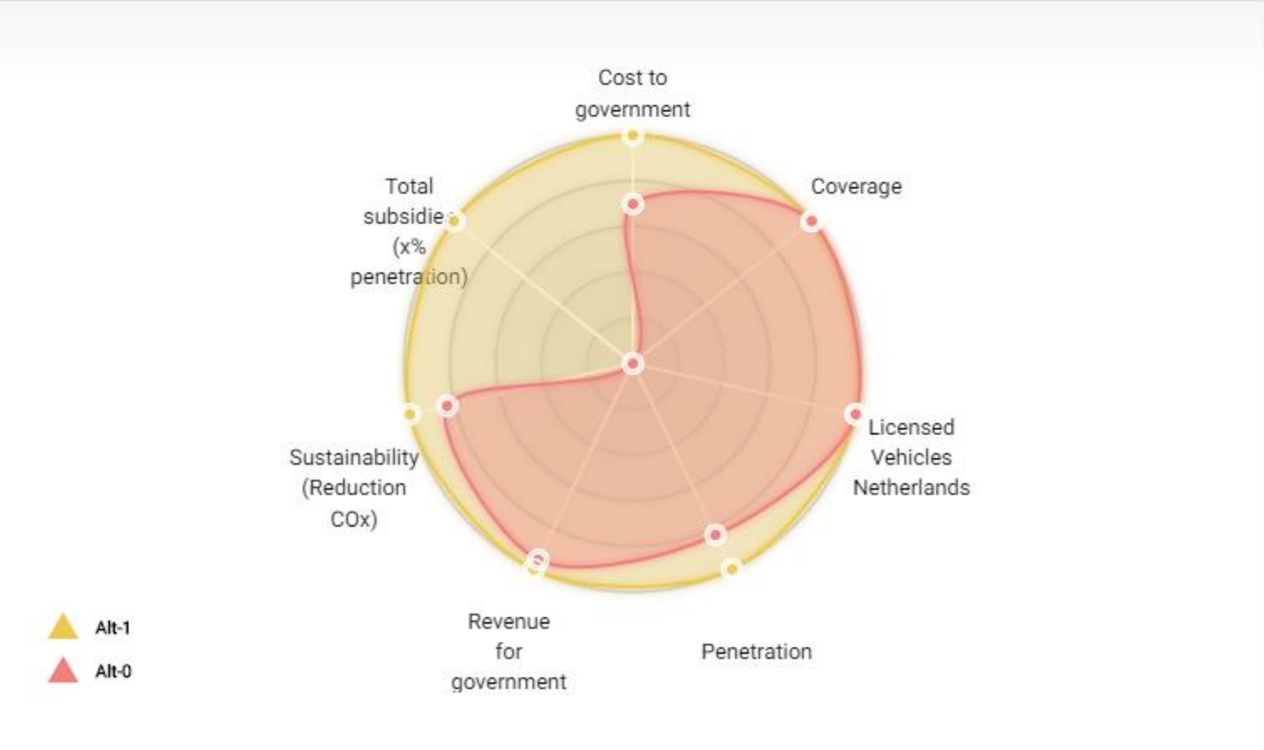

Figure 24: Radar view of plan values with Alt-0 = ITS-G, 5Alt-1 = ITS-G5: subsidized.

The above example is only an illustration of one of the many possible regulations that can the government can consider to implement. This process can be repeated, with small adaptations, for other types of regulations and what-if scenarios (as discussed in 2.2.10). Some of these alternatives will require a more structural variation of the model, which is supported by the VMP.

4.3.3 Conclusion of the complementary use of both methods.

Regulators who seek to view the impact of regulations on participants in the value web can definitely benefit from both the VMP and DAMIAN. Each approach has its specific focus and when implementing new regulations in emerging data driven innovation ecosystems, both can provide valuable insights to support discussion and decision making. As DAMIAN focusses more on intangible relationships within the ecosystem, the VMP can add value by providing a more detailed view of the values of the participants and introduce more explicit tangible flows. The VMP also allows for a phased implementation of the regulation, which is useful if technologies to which it applies have not yet reached maturity. The introduction of new regulations, as considered by DAMIAN, can easily be modeled in the VMP through the creation of new alternatives (see 4.3.2). This allows policy makers to quickly capture the impact of new regulations on the balance of power in the value web in greater detail than DAMIAN. As participants are subjected to different types of regulations, measurements of values change accordingly. When presenting new regulations, the dashboard in the value management platform allows users to rapidly create overviews of the consequences by the introduction of each of these regulations.

In other words, the complementary approach allows regulators and other modelers to quickly see the results on measurable plan values in different scenarios, and play more easily with regulations whilst considering the different needs of each of the industries to which it applies. Discussions would be more efficient and arguments for the implementation of regulation better founded, as they backed by the results of a model.

5. Conclusion

The VMP offers many possibilities to support the DAMIAN approach in the field of data driven innovations. First of all, through the use of alternatives, regulators can easily implement new regulations or asses different what-if scenarios as covered in step 7 and 10 in DAMIAN. If new actors, that follow a different route through the value web, would appear on the market, a new alternative can be generated in the VMP. This alternative can contain the additional business model of this participant, the links it has, and it can be generated with minimal effort. Secondly, the business ecosystem map as developed by VDMbee gives a clear overview of the different exchanges and can provide another angle on the routes as depicted in the service delivery canvas by DAMIAN. The VMP allows for measurements to be added to values, which are defined more explicitly than in the DAMIAN approach. Lastly, through the use of the VMP, users can easily create (graphical) overviews that allows for comparison of the measurements of values exchanged across different alternative scenarios as can be used for the discussions in step 9 of DAMIAN. The measurements of these values can also give a further detail in the different tensions and conflicts, providing a link with step 8 of DAMIAN.

Although the VMP and DAMIAN approach have different objectives, several overlaps were identified. First of all, the metamodels of both DAMIAN and VMP contain several identical classes. Some of these were viewed from another perspective and consequently were linked differently (e.g. assets and activities). Other overlaps allowed for the identification of participants, and thus permits reduced effort when identifying participants. The modeling method of VMP supports the multiple route delivery as described by the value web view of DAMIAN. Consequently the impact of each of these routes by the introduction of a new regulation can be easily seen (through the use of different alternatives), which can be considered to be a perquisite for efficient discussions, which is a goal also endeavored by DAMIAN.

Data driven innovations in the field of wireless technologies that require totally new infrastructure, are by definition Greenfield situations. The VMP allows modelers to start from both an existing model or from scratch and thus seems like the perfect tool to form the base of the discussion for a phased implementation or evaluation of these kinds of innovations. The stepwise technique the VMP wields provides a good structure to support the different steps of DAMIAN, and allows for both methods to be used complementary. This complementary use of both methods is recommended if the impact of regulation on data driven innovations and the involved participants is to be evaluated. The complementary use allows all relevant values to be defined, measured and viewed in different scenarios, which advocates efficient discussions with accurate, model-supported arguments concerning implementation of new regulation. This is useful for policy makers, participants subject to this regulation as well as potential entrants to this market.

In the case of IVS, there are a lot of regulations and scenarios that can be explored in addition to the alternatives provided here. Future research could be aimed towards identifying these regulations and implementing more domain specific values and realistic measurements for the values that already have been identified. If IVS would be implemented in the Netherlands in collaboration with the VMP, its phased approach would allow regulators to adapt their models during the different phases in response to how the market reacts, and let make more accurate decisions based on realistic forecasts. Further identification of complementarity between the business ecosystem map of the VMP and service delivery canvas of DAMIAN could potentially reveal additional benefits when similar concepts (such as activities and assets) are linked.

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Appendixes

Appendix 1. IVS

ITS-G5	4G LTE
Technical characteristics - Coverage: 300m-1km - Capacity: enough to support safety and efficiency applications. - Quality of Service: Very high - Transmission time: <5ms - Latency <100ms including security operations	Technical characteristics - Coverage: 10km - Capacity: good. However can be overloaded, so ITS G5 is best suited to carry CAM* traffic. - Quality of Service: Best effort - Transmission time: Fast - Latency 50-150ms *CAM ((Cooperative Awareness Message) this is a periodic message sent one to ten times per second with data on the vehicles position, direction, speed etc.
Costs - OBU - Roadside ITS stations - Electrical power, civil works, internet connection, operation cost, maintenance cost - Lifetime of equipment is estimated at 10 years - Lower variable cost than 4G LTE - Higher reliability than LTE	Costs - Subscription fees - Communication costs similar to smartphones to cover investment and operations

Table 15: comparison of ITS-G5 and 4G LTE characteristics (van den Ende, van Sambeek, Berkers, van den Broeck, & van de Sluis, 2016).

Appendix 2. DAMIAN

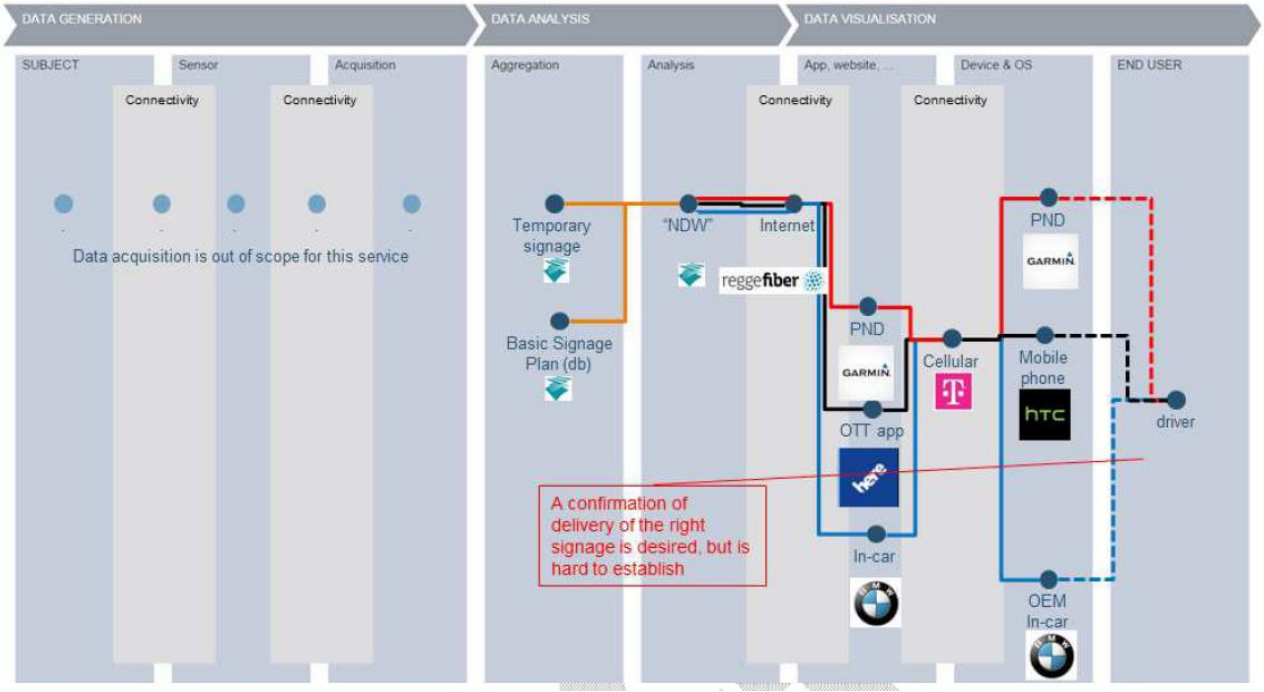

Figure 25: Business model canvas for Model II : 4G/5G

Appendix 3. VMP Model I: Plan values

Avg emission per km	0.107 Kg COx
Avg emission per year	21400.000 Ton COx
Avg km per year per driver	20000.00 km/year per driver
Cost to government	243.53 million euro
Coverage	100.00 %
Licensed Vehicles Netherlands	10.00 million drivers
Mobile phone provider market share	
OEM provider market share	50.00 %
Penetration	50.00 %
PND provider market share	
PRO provider market share	50.00 %
Quality of service (max. duration of breakdown)	
% reduction of COx per km	2.00 %
Reliability (% of uptime)	
Revenue for government	575.00 million euro
Safety increase	
Security	
Subsidies	
Sustainability (Reduction COx)	214.000 Ton COx
Total subsidies (x% penetration)	
Traffic flow (yearly avg of traffic jams)	

Table 16: Plan values of Model I: ITS-G5

Appendix 4. VMP Model I: Business ecosystem maps

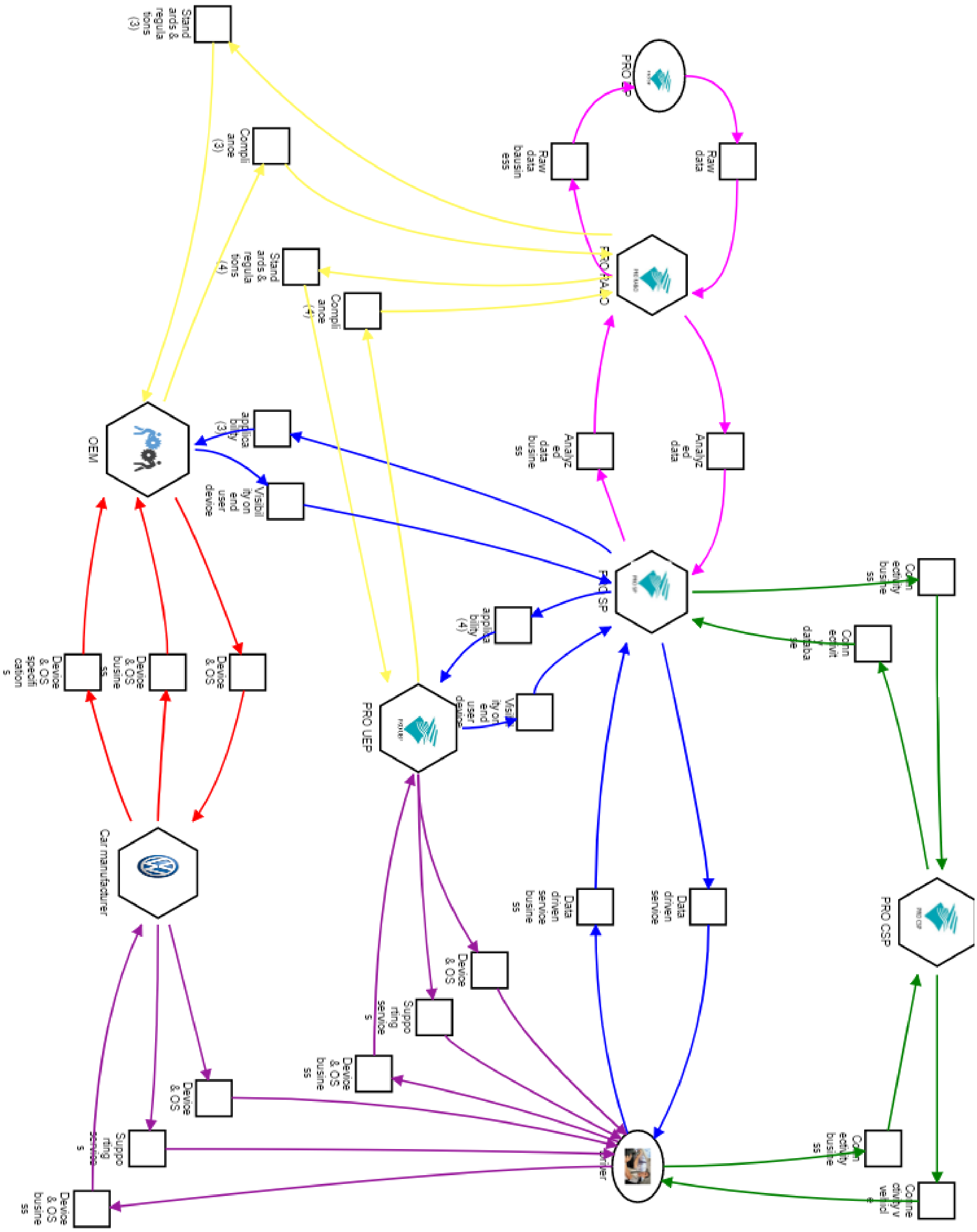

Figure 26: Business ecosystem map, participants modeled as business models (hexagons) and roles (ovals)

Appendix 5. VMP Model I: Participant networks

Participant Network	My Business (Role)	Customers (Role)	Partners (Role)	Other Participants (Role)
ITS - G5	PRO - CSP (Connectivity provider)	PRO - SP (Data transmittor) , Driver (Data receiver)		

Table 17: Participant networks and their actors of business model cube Connectivity (Model I: ITS-G5)

Participant Network	My Business (Role)	Customers (Role)	Partners (Role)	Other Participants (Role)
Data	PRO - RA&O (Road operator)	PRO - SP (Analyzed data receiver)	PRO - DP (Data provider)	
Fabrication	PRO - RA&O (Device regulator)	PRO - UEP (After Market Device fabricator) , OEM (In Vehicle Device fabricator)		

Table 18: Participant networks and their actors of business model cube Data (Model I: ITS-G5)

Participant Network	My Business (Role)	Customers (Role)	Partners (Role)	Other Participants (Role)
Fabrication	OEM (In Vehicle Device fabricator)		PRO - RA&O (Device regulator)	PRO - UEP (After Market Device fabricator)
IVS	OEM (In Vehicle Device manufacturer)		PRO - SP (Service Provider)	Driver (End user), PRO - UEP (After Market Device manufacturer)
Outsourcing	OEM (Contractor)	Car Manufacturer (In vehicle Device purchaser)		

Table 19: Participant networks and their actors of business model cube Device OEM (Model I: ITS-G5)

Participant Network	My Business (Role)	Customers (Role)	Partners (Role)	Other Participants (Role)
Device	PRO - UEP (After market Device provider)	Driver (End user)		Car Manufacturer (In vehicle Device provider)
Fabrication	PRO - UEP (After Market Device fabricator)		PRO - RA&O (Device regulator)	OEM (In Vehicle Device fabricator)
IVS	PRO - UEP (After Market Device manufacturer)		PRO - SP (Service Provider)	Driver (End user), OEM (In Vehicle Device manufacturer)

Table 20: Participant networks and their actors of business model cube Device PRO (Model I: ITS-G5)

Participant Network	My Business (Role)	Customers (Role)	Partners (Role)	Other Participants (Role)
Device	Car Manufacturer (In vehicle Device provider)	Driver (End user)		PRO - UEP (After market Device provider)
Outsourcing	Car Manufacturer (In vehicle Device purchaser)		OEM (Contractor)	

Table 21: Participant networks and their actors of business model cube Vehicle (Model I: ITS-G5)

Appendix 6. VMP Model I: Value propositions

Value Proposition	From (Role)	To (Role)	Values
Connectivity business ***[ITS - G5 / Data receiver]***	Driver (Data receiver ***(Customer)***)	PRO - CSP (Connectivity provider ***(Business)***)	
Connectivity business ***[ITS - G5 / Data transmittor]***	PRO - SP (Data transmittor ***(Customer)***)	PRO - CSP (Connectivity provider ***(Business)***)	
Connectivity database	PRO - CSP (Connectivity provider ***(Business)***)	PRO - SP (Data transmittor ***(Customer)***)	Connectivity database cost 1.10 million euro/year -> Connectivity database cost 4 (x% coverage) 1.10 million euro/year Connectivity database cost 4 (x% coverage) 1.10 million euro/year -> Connectivity cost (x% coverage) 2.30 million euro/year (ITS - G5 result)
Connectivity vehicle	PRO - CSP (Connectivity provider ***(Business)***)	Driver (Data receiver ***(Customer)***)	Connectivity vehicle cost 1.20 million euro/year -> Connectivity vehicle cost (x% coverage) 1.20 million euro/year Connectivity vehicle cost (x% coverage) 1.20 million euro/year -> Connectivity cost (x% coverage) 2.30 million euro/year (ITS - G5 result)

Table 22: Value propositions of business model cube Connectivity (Model I: ITS-G5)

Value Proposition	From (Role)	To (Role)	Values
Analyzed data	PRO - RA&O (Road operator ***(Business)***)	PRO - SP (Analyzed data receiver ***(Customer)***)	Analyzed data cost 1.10 million euro/year -> Total data cost 16.10 million euro/year (Data result)
Analyzed data business	PRO - SP (Analyzed data receiver ***(Customer)***)	PRO - RA&O (Road operator ***(Business)***)	
Compliance (3)	OEM (In Vehicle Device fabricator ***(Customer)***)	PRO - RA&O (Device regulator ***(Business)***)	
Compliance (4)	PRO - UEP (After Market Device fabricator ***(Customer)***)	PRO - RA&O (Device regulator ***(Business)***)	
Raw data	PRO - DP (Data provider ***(Partner)***)	PRO - RA&O (Road operator ***(Business)***)	Raw data cost 15.00 million euro/year -> Raw data cost (x% coverage) 15.00 million euro/year Raw data cost (x% coverage) 15.00 million euro/year -> Total data cost 16.10 million euro/year (Data result)
Raw data business	PRO - RA&O (Road operator ***(Business)***)	PRO - DP (Data provider ***(Partner)***)	
Standards & regulation (3)	PRO - RA&O (Device regulator ***(Business)***)	OEM (In Vehicle Device fabricator ***(Customer)***)	Standards & regulations cost 0.03 million euro -> Total Standards & regulations cost 0.03 million euro (Fabrication result)
Standards & regulation (4)	PRO - RA&O (Device regulator ***(Business)***)	PRO - UEP (After Market Device fabricator ***(Customer)***)	Standards & regulations cost 0.03 million euro -> Total Standards & regulations cost 0.03 million euro (Fabrication result)

Table 23: Value propositions of business model cube Data (Model I: ITS-G5)

Value Proposition	From (Role)	To (Role)	Values
Applicability (3)	PRO - SP (Service Provider ***(Partner)***)	OEM (In Vehicle Device manufacturer ***(Business)***)	
Compliance (3)	OEM (In Vehicle Device fabricator ***(Business)***)	PRO - RA&O (Device regulator ***(Partner)***)	
Device & OS	OEM (Contractor ***(Business)***)	Car Manufacturer (In vehicle Device purchaser ***(Customer)***)	OEM Device price 101.00 euro/device -> (In-car device cost 111.00 euro/device (Device & OS business [Device / End user]), OEM total device revenues 252.50 million euro (Outsourcing result))
Device & OS business	Car Manufacturer (In vehicle Device purchaser ***(Customer)***)	OEM (Contractor ***(Business)***)	OEM Device cost 81.00 euro/device -> (OEM Device price 101.00 euro/device (Device & OS), OEM total device costs 202.50 milliion euro (Outsourcing result)) OEM Device mark-up 20.00 euro/device -> OEM Device price 101.00 euro/device (Device & OS) OEM Device sales 2.50 million device(s) -> (OEM total device revenues 252.50 million euro (Outsourcing result), OEM total device costs 202.50 milliion euro (Outsourcing result), Total in car device revenues 302.50 million euro (Device result), Total in-car device cost 277.50 million euro (Device result)) OEM Device sales Market share 50.00 % -> OEM Device sales 2.50 million device(s)
Device & OS business specifications	Car Manufacturer (In vehicle Device purchaser ***(Customer)***)	OEM (Contractor ***(Business)***)	Dimensions
Standards & regulation (3)	PRO - RA&O (Device regulator ***(Partner)***)	OEM (In Vehicle Device fabricator ***(Business)***)	Standards & regulations cost 0.03 million euro -> Total Standards & regulations cost 0.03 million euro (Fabrication result)
Visibility on End-User device	OEM (In Vehicle Device manufacturer ***(Business)***)	PRO - SP (Service Provider ***(Partner)***)	

Table 24: Value propositions of business model cube Device OEM (Model I: ITS-G5)

Value Proposition	From (Role)	To (Role)	Values
Applicability (4)	PRO - SP (Service Provider ***(Partner)***)	PRO - UEP (After Market Device manufacturer ***(Business)***)	
Compliance (4)	PRO - UEP (After Market Device fabricator ***(Business)***)	PRO - RA&O (Device regulator ***(Partner)***)	
Device & OS	PRO - UEP (After market Device provider ***(Business)***)	Driver (End user ***(Customer)***)	PRO Device price 110.00 euro/device -> PRO total device revenues 275.00 million euro (Device result) PRO Sales cost 10.00 euro/device -> PRO device sales costs 25.00 million euro (Device result)
Device business	Driver (End user ***(Customer)***)	PRO - UEP (After market Device provider ***(Business)***)	PRO Device cost 80.00 euro/device -> (PRO Device price 110.00 euro/device (Device & OS), PRO total device costs 200.00 million euro (Device result)) PRO Device mark-up 20.00 euro/device -> PRO Device price 110.00 euro/device (Device & OS) PRO Device sales 2.50 million device(s) -> (PRO total device costs 200.00 million euro (Device result), PRO total device revenues 275.00 million euro (Device result), PRO device sales costs 25.00 million euro (Device result)) PRO Device sales Market share 50.00 % -> PRO Device sales 2.50 million device(s)
Standards & regulation (4)	PRO - RA&O (Device regulator ***(Partner)***)	PRO - UEP (After Market Device fabricator ***(Business)***)	Standards & regulations cost 0.03 million euro -> Total Standards & regulations cost 0.03 million euro (Fabrication result)
Supporting services	PRO - UEP (After Market Device fabricator ***(Business)***)	Driver (End user ***(Customer)***)	Warranty cost per device sent back 50.00 euro/device
Visibility on End-user device	PRO - UEP (After Market Device manufacturer ***(Business)***)	PRO - SP (Service Provider ***(Partner)***)	

Table 25: Value propositions of business model cube Device PRO (Model I: ITS-G5)

Value Proposition	From (Role)	To (Role)	Values
Device & OS	OEM (Contractor *(Partner)*)	Car Manufacturer (In vehicle Device purchaser *(Business)*)	OEM Device price 101.00 euro/device -> (In-car device cost 111.00 euro/device (Device & OS business [Device / End user]), OEM total device revenues 252.50 million euro (Outsourcing result))
Device & OS business *[Device / End user]*	Driver (End user *(Customer)*)	Car Manufacturer (In vehicle Device provider *(Business)*)	In-car device cost 111.00 euro/device -> (In-car device option price 121.00 euro/device (Device & OS option), Total in-car device cost 277.50 million euro (Device result)) In-car device mark up 10.00 euro/device -> In-car device option price 121.00 euro/device (Device & OS option)
Device & OS business *[Outsourcing / In vehicle Device purchaser]*	Car Manufacturer (In vehicle Device purchaser *(Business)*)	OEM (Contractor *(Partner)*)	OEM Device cost 81.00 euro/device -> (OEM Device price 101.00 euro/device (Device & OS), OEM total device costs 202.50 milliion euro (Outsourcing result)) OEM Device mark-up 20.00 euro/device -> OEM Device price 101.00 euro/device (Device & OS) OEM Device sales 2.50 million device(s) -> (OEM total device revenues 252.50 million euro (Outsourcing result), OEM total device costs 202.50 milliion euro (Outsourcing result), Total in car device revenues 302.50 million euro (Device result), Total in-car device cost 277.50 million euro (Device result)) OEM Device sales Market share 50.00 % -> OEM Device sales 2.50 million device(s)
Device & OS business specifications	Car Manufacturer (In vehicle Device purchaser *(Business)*)	OEM (Contractor *(Partner)*)	Dimensions
Device & OS option	Car Manufacturer (In vehicle Device provider *(Business)*)	Driver (End user *(Customer)*)	In-car device option price 121.00 euro/device -> Total in car device revenues 302.50 million euro (Device result)
Supporting services	Car Manufacturer (In vehicle Device provider *(Business)*)	Driver (End user *(Customer)*)	

Table 26: Value propositions of business model cube Vehicle (Model I: ITS-G5)

Appendix 7. VMP Model I: My propositions

My Proposition	From (Role)	Values
ITS - G5 result	Connectivity provider	Connectivity cost (x% coverage) 2.30 million euro/year -> Cost to government 243.53 million euro (C-ITS (new))

Table 27: My proposition of business model cube Connectivity (Model I: ITS-G5)

My Proposition	From (Role)	Values
Data result	Road operator	Total data cost 16.10 million euro/year -> Cost to government 243.53 million euro (C-ITS (new))
Fabrication result	Device regulator	Total Standards & regulations cost 0.03 million euro -> Cost to government 243.53 million euro (C-ITS (new))

Table 28: My proposition of business model cube Data (Model I: ITS-G5)

My Proposition	From (Role)	Values
Outsourcing result	Contractor	OEM total device costs 202.50 milliion euro -> OEM total profit 50.00 million euro OEM total device revenues 252.50 million euro -> OEM total profit 50.00 million euro

Table 29: My proposition of business model cube Device OEM (Model I: ITS-G5)

My Proposition	From (Role)	Values
Device result	After market Device provider	PRO device sales costs 25.00 million euro -> (PRO total profit 50.00 million euro, Cost to government 243.53 million euro (C-ITS (new))) PRO total device costs 200.00 million euro -> (PRO total profit 50.00 million euro, Cost to government 243.53 million euro (C-ITS (new))) PRO total device revenues 275.00 million euro -> (PRO total profit 50.00 million euro, Revenue for government 575.00 million euro (C-ITS (new)))

Table 30: My proposition of business model cube Device PRO (Model I: ITS-G5)

My Proposition	From (Role)	Values
Device result	In vehicle Device provider	Total in-car device cost 277.50 million euro -> Total in-car device profit 25.00 million euro Total in car device revenues 302.50 million euro -> Total in-car device profit 25.00 million euro

Table 31: My proposition of business model cube Vehicle (Model I: ITS-G5)

Appendix 8. VMP Model I: Activities

Pursued	Participant (Role)	Activities	Values
Connectivity database	PRO - CSP (Connectivity provider ***(Business)***)	Configure & operate the network , Distribute information , Invest in ITS-G5 transmission infrastructure	ITS-G5 transmission infrastructure depreciation 1.00 million euro/year (Invest in ITS-G5 transmission infrastructure) -> Connectivity database cost 1.10 million euro/year (Connectivity database) Network operating cost 0.10 million euro/year (Configure & operate the network) -> Connectivity database cost 1.10 million euro/year (Connectivity database)
Connectivity vehicle	PRO - CSP (Connectivity provider ***(Business)***)	Configure & operate RSU , Distribute information , Invest in ITS-G5 RSU infrastructure , Support the network	RSU depreciation 1.00 million euro/year (Invest in ITS-G5 RSU infrastructure) -> Connectivity vehicle cost 1.20 million euro/year (Connectivity vehicle) RSU maintenance 0.10 million euro/year (Configure & operate RSU) -> Connectivity vehicle cost 1.20 million euro/year (Connectivity vehicle) RSU operating cost 0.10 million euro/year (Configure & operate RSU) -> Connectivity vehicle cost 1.20 million euro/year (Connectivity vehicle)

Table 32: Activities of business model Connectivity (Model I: IT-G5)

Pursued	Participant (Role)	Activities	Values
Analyzed data	PRO - RA&O (Road operator ***(Business)***)	Apply algorithms , Forward relevant data , Invest in algorithms , Receive & store data	Algorithms development cost 0.10 million euro/year (Invest in algorithms) -> Analyzed data cost 1.10 million euro/year (Analyzed data) Hardware & software cost 1.00 million euro/year (Apply algorithms) -> Analyzed data cost 1.10 million euro/year (Analyzed data)
Raw data	PRO - DP (Data provider ***(Partner)***)	Add appropriate time stamp and location referencing , Categorize data , Format data , Receive data , Remove unreliable or irrelevant data	Data gathering cost 10.00 million euro/year (Receive data) -> Raw data cost 15.00 million euro/year (Raw data) Data processing cost 5.00 million euro/year (Format data) -> Raw data cost 15.00 million euro/year (Raw data)
Standards & regulation (3)	PRO - RA&O (Device regulator ***(Business)***)	Devise regulations , Legalize regulations , Test regulations	Devise regulations cost 0.01 million euro (Devise regulations) -> Standards & regulations cost 0.03 million euro (Standards & regulation (3)), Standards & regulations cost 0.03 million euro (Standards & regulation (4)) Legalize regulations cost 0.01 million euro (Legalize regulations) -> Standards & regulations cost 0.03 million euro (Standards & regulation (3)) Test regulations cost 0.01 million euro (Test regulations) -> Standards & regulations cost 0.03 million euro (Standards & regulation (3)), Standards & regulations cost 0.03 million euro (Standards & regulation (4))
Standards & regulation (4)	PRO - RA&O (Device regulator ***(Business)***)	Devise regulations , Legalize regulations. , Test regulations	Devise regulations cost 0.01 million euro (Devise regulations) -> Standards & regulations cost 0.03 million euro (Standards & regulation (3)), Standards & regulations cost 0.03 million euro (Standards & regulation (4)) Legalize regulations cost 0.01 million euro (Legalize regulations.) -> Standards & regulations cost 0.03 million euro (Standards & regulation (4)) Test regulations cost 0.01 million euro (Test regulations) -> Standards & regulations cost 0.03 million euro (Standards & regulation (3)), Standards & regulations cost 0.03 million euro (Standards & regulation (4))

Table 33: Activities of business model Data (Model I: IT-G5)

Pursued	Participant (Role)	Activities	Values
Device & OS business	OEM (Contractor ***(Business)***)	Assemble devices , Order parts , Ship devices	Assembling cost 3 20.00 euro/device (Assemble devices) -> OEM Device cost 81.00 euro/device (Device & OS business) Parts cost 3 60.00 euro/device (Assemble devices) -> OEM Device cost 81.00 euro/device (Device & OS business) Transportation cost 3 1.00 euro/device (Assemble devices) -> OEM Device cost 81.00 euro/device (Device & OS business)

Table 34: Activities of business model cube Device OEM (Model I: IT-G5)

Pursued	Participant (Role)	Activities	Values
Device & OS	PRO - UEP (After market Device provider ***(Business)***)	Sell devices	Sales cost 10.00 euro/device (Sell devices) -> PRO Device price 110.00 euro/device (Device & OS), PRO Sales cost 10.00 euro/device (Device & OS)
Device business	PRO - UEP (After Market Device manufacturer ***(Business)***)	Assemble devices , Order parts	Assembling cost 4 20.00 euro/device (Assemble devices) -> PRO Device cost 80.00 euro/device (Device business) Parts cost 4 60.00 euro/device (Assemble devices) -> PRO Device cost 80.00 euro/device (Device business)

Table 35: Activities of business model cube Device PRO (Model I: IT-G5)

Pursued	Participant (Role)	Activities	Values
Device & OS business	Car Manufacturer (In vehicle Device provider ***(Business)***)	Install device	Installation cost 10.00 euro/device (Install device) -> In-car device cost 111.00 euro/device (Device & OS business [Device / End user])
Device & OS option	Car Manufacturer (In vehicle Device purchaser ***(Business)***)	Purchase device	

Table 36: Activities of business model cube Vehicle (Model I: IT-G5)

Appendix 9. VMP Model I: Values

Name	Value	Satisfaction	Recipient Opinion	From (Role)	To (Role)
Adjusted speed limit				PRO - SP (Service Provider ***(Business)***)	Driver (End user ***(Customer)***)
Analyzed data cost	1.10 million euro/year	fair		PRO - RA&O (Road operator ***(Partner)***)	PRO - SP (Analyzed data receiver ***(Business)***)
Connectivity database cost	1.10 million euro/year	fair		PRO - CSP (Connectivity provider ***(Partner)***)	PRO - SP (Data transmittor ***(Business)***)
Connectivity database cost 4 (x% coverage)	1.10 million euro/year	fair		PRO - CSP (Connectivity provider ***(Partner)***)	PRO - SP (Data transmittor ***(Business)***)
Customer base (100% penetration)	10.00 million drivers	fair		Driver (End user ***(Customer)***)	PRO - SP (Service Provider ***(Business)***)
Customer base (x% penetration)	5.00 million drivers	fair		Driver (End user ***(Customer)***)	PRO - SP (Service Provider ***(Business)***)
Customer satisfaction				PRO - SP (Service Provider ***(Business)***)	
Data driven service cost 4	0.10 million euro/year	fair		PRO - SP (Service Provider ***(Business)***)	
Data driven service revenues	300.00 million euro/year	fair		PRO - SP (Service Provider ***(Business)***)	
PRO app & website cost	0.10 million euro/year			PRO - SP (Service Provider ***(Business)***)	
PRO app & website cost	0.10 million euro/year	fair		Driver (End user ***(Customer)***)	PRO - SP (Service Provider ***(Business)***)
Road surface warnings				PRO - SP (Service Provider ***(Business)***)	Driver (End user ***(Customer)***)
Weather conditions				PRO - SP (Service Provider ***(Business)***)	Driver (End user ***(Customer)***)
Yearly service provision fee	60.00 euro/year	fair		PRO - SP (Service Provider ***(Business)***)	Driver (End user ***(Customer)***)

Table 37: Values of business model cube IVS (Model I: ITS-G5)

Name	Value	Satisfaction	Recipient Opinion	From (Role)	To (Role)
Connectivity cost (x% coverage)	2.30 million euro/year	fair ☺		PRO - CSP (Connectivity provider *(Business)*)	
Connectivity database cost	1.10 million euro/year	fair ☺		PRO - CSP (Connectivity provider *(Business)*)	PRO - SP (Data transmittor *(Customer)*)
Connectivity database cost 4 (x% coverage)	1.10 million euro/year	fair ☺		PRO - CSP (Connectivity provider *(Business)*)	PRO - SP (Data transmittor *(Customer)*)
Connectivity vehicle cost	1.20 million euro/year	fair ☺		PRO - CSP (Connectivity provider *(Business)*)	Driver (Data receiver *(Customer)*)
Connectivity vehicle cost (x% coverage)	1.20 million euro/year	fair ☺		PRO - CSP (Connectivity provider *(Business)*)	Driver (Data receiver *(Customer)*)
ITS-G5 transmission infrastructure depreciation	1.00 million euro/year			PRO - CSP (Connectivity provider *(Business)*)	
Network operating cost	0.10 million euro/year			PRO - CSP (Connectivity provider *(Business)*)	
RSU depreciation	1.00 million euro/year			PRO - CSP (Connectivity provider *(Business)*)	
RSU maintenance	0.10 million euro/year			PRO - CSP (Connectivity provider *(Business)*)	
RSU operating cost	0.10 million euro/year			PRO - CSP (Connectivity provider *(Business)*)	

Table 38: Values of business model cube Connectivity (Model I: ITS-G5)

Name	Value	Satisfaction	Recipient Opinion	From (Role)	To (Role)
Algorithms development cost	0.10 million euro/year			PRO - RA&O (Road operator *(Business)*)	
Analyzed data cost	1.10 million euro/year	fair ☺		PRO - RA&O (Road operator *(Business)*)	PRO - SP (Analyzed data receiver *(Customer)*)
Data gathering cost	10.00 million euro/year			PRO - DP (Data provider *(Partner)*)	
Data processing cost	5.00 million euro/year			PRO - DP (Data provider *(Partner)*)	
Devise regulations cost	0.01 million euro			PRO - RA&O (Device regulator *(Business)*)	
Hardware & software cost	1.00 million euro/year			PRO - RA&O (Road operator *(Business)*)	
Legalize regulations cost	0.01 million euro			PRO - RA&O (Device regulator *(Business)*)	
Legalize regulations cost	0.01 million euro			PRO - RA&O (Device regulator *(Business)*)	
Raw data cost	15.00 million euro/year	fair ☺		PRO - DP (Data provider *(Partner)*)	PRO - RA&O (Road operator *(Business)*)
Raw data cost (x% coverage)	15.00 million euro/year	fair ☺		PRO - DP (Data provider *(Partner)*)	PRO - RA&O (Road operator *(Business)*)
Standards & regulations cost	0.03 million euro	fair ☺		PRO - RA&O (Device regulator *(Business)*)	PRO - UEP (After Market Device fabricator *(Customer)*)
Standards & regulations cost	0.03 million euro	fair ☺		PRO - RA&O (Device regulator *(Business)*)	OEM (In Vehicle Device fabricator *(Customer)*)
Test regulations cost	0.01 million euro			PRO - RA&O (Device regulator *(Business)*)	
Total data cost	16.10 million euro/year	fair ☺		PRO - RA&O (Road operator *(Business)*)	
Total Standards & regulations cost	0.03 million euro	fair ☺		PRO - RA&O (Device regulator *(Business)*)	

Table 39: Values of business model cube Data (Model I: ITS-G5)

Name	Value	Satisfaction	Recipient Opinion	From (Role)	To (Role)
Assembling cost 3	20.00 euro/device			OEM (Contractor ***(Business)***)	
Dimensions				Car Manufacturer (In vehicle Device purchaser ***(Customer)***)	OEM (Contractor ***(Business)***)
OEM Device cost	81.00 euro/device	fair ☺		Car Manufacturer (In vehicle Device purchaser ***(Customer)***)	OEM (Contractor ***(Business)***)
OEM Device mark-up	20.00 euro/device	fair ☺		Car Manufacturer (In vehicle Device purchaser ***(Customer)***)	OEM (Contractor ***(Business)***)
OEM Device price	101.00 euro/device	fair ☺		OEM (Contractor ***(Business)***)	Car Manufacturer (In vehicle Device purchaser ***(Customer)***)
OEM Device sales	2.50 million device(s)	fair ☺		Car Manufacturer (In vehicle Device purchaser ***(Customer)***)	OEM (Contractor ***(Business)***)
OEM Device sales Market share	50.00 %	fair ☺		Car Manufacturer (In vehicle Device purchaser ***(Customer)***)	OEM (Contractor ***(Business)***)
OEM total device costs	202.50 milliion euro	fair ☺		OEM (Contractor ***(Business)***)	
OEM total device revenues	252.50 million euro	fair ☺		OEM (Contractor ***(Business)***)	
OEM total profit	50.00 million euro	fair ☺		OEM (Contractor ***(Business)***)	
Parts cost 3	60.00 euro/device			OEM (Contractor ***(Business)***)	
Standards & regulations cost	0.03 million euro	fair ☺		PRO - RA&O (Device regulator ***(Partner)***)	OEM (In Vehicle Device fabricator ***(Business)***)
Transportation cost 3	1.00 euro/device			OEM (Contractor ***(Business)***)	

Table 40: Values of business model cube Device OEM (Model I: ITS-G5)

Name	Value	Satisfaction	Recipient Opinion	From (Role)	To (Role)
Assembling cost 4	20.00 euro/device			PRO - UEP (After Market Device manufacturer ***(Business)***)	
Parts cost 4	60.00 euro/device			PRO - UEP (After Market Device manufacturer ***(Business)***)	
PRO Device cost	80.00 euro/device	fair ☺		Driver (End user ***(Customer)***)	PRO - UEP (After market Device provider ***(Business)***)
PRO Device mark-up	20.00 euro/device	fair ☺		Driver (End user ***(Customer)***)	PRO - UEP (After market Device provider ***(Business)***)
PRO Device price	110.00 euro/device	fair ☺		PRO - UEP (After market Device provider ***(Business)***)	Driver (End user ***(Customer)***)
PRO Device sales	2.50 million device(s)	fair ☺		Driver (End user ***(Customer)***)	PRO - UEP (After market Device provider ***(Business)***)
PRO device sales costs	25.00 million euro	fair ☺		PRO - UEP (After market Device provider ***(Business)***)	
PRO Device sales Market share	50.00 %	fair ☺		Driver (End user ***(Customer)***)	PRO - UEP (After market Device provider ***(Business)***)
PRO Sales cost	10.00 euro/device	fair ☺		PRO - UEP (After market Device provider ***(Business)***)	Driver (End user ***(Customer)***)
PRO total device costs	200.00 million euro	fair ☺		PRO - UEP (After market Device provider ***(Business)***)	
PRO total device revenues	275.00 million euro	fair ☺		PRO - UEP (After market Device provider ***(Business)***)	
PRO total profit	50.00 million euro	fair ☺		PRO - UEP (After market Device provider ***(Business)***)	
Sales cost	10.00 euro/device			PRO - UEP (After market Device provider ***(Business)***)	
Standards & regulations cost	0.03 million euro	fair ☺		PRO - RA&O (Device regulator ***(Partner)***)	PRO - UEP (After Market Device fabricator ***(Business)***)
Warranty cost per device sent back	50.00 euro/device	fair ☺		PRO - UEP (After Market Device fabricator ***(Business)***)	Driver (End user ***(Customer)***)

Table 41: Values of business model cube Device PRO (Model I: ITS-G5)

Name	Value	Satisfaction	Recipient Opinion	From (Role)	To (Role)
Dimensions				Car Manufacturer (In vehicle Device purchaser ***(Business)***)	OEM (Contractor ***(Partner)***)
In-car device cost	111.00 euro/device	fair ☺		Driver (End user ***(Customer)***)	Car Manufacturer (In vehicle Device provider ***(Business)***)
In-car device mark up	10.00 euro/device	fair ☺		Driver (End user ***(Customer)***)	Car Manufacturer (In vehicle Device provider ***(Business)***)
In-car device option price	121.00 euro/device	fair ☺		Car Manufacturer (In vehicle Device provider ***(Business)***)	Driver (End user ***(Customer)***)
Installation cost	10.00 euro/device			Car Manufacturer (In vehicle Device provider ***(Business)***)	
OEM Device cost	81.00 euro/device	fair ☺		Car Manufacturer (In vehicle Device purchaser ***(Business)***)	OEM (Contractor ***(Partner)***)
OEM Device mark-up	20.00 euro/device	fair ☺		Car Manufacturer (In vehicle Device purchaser ***(Business)***)	OEM (Contractor ***(Partner)***)
OEM Device price	101.00 euro/device	fair ☺		OEM (Contractor ***(Partner)***)	Car Manufacturer (In vehicle Device purchaser ***(Business)***)
OEM Device sales	2.50 million device(s)	fair ☺		Car Manufacturer (In vehicle Device purchaser ***(Business)***)	OEM (Contractor ***(Partner)***)
OEM Device sales Market share	50.00 %	fair ☺		Car Manufacturer (In vehicle Device purchaser ***(Business)***)	OEM (Contractor ***(Partner)***)
Total in-car device cost	277.50 million euro	fair ☺		Car Manufacturer (In vehicle Device provider ***(Business)***)	
Total in-car device profit	25.00 million euro	fair ☺		Car Manufacturer (In vehicle Device provider ***(Business)***)	
Total in car device revenues	302.50 million euro	fair ☺		Car Manufacturer (In vehicle Device provider ***(Business)***)	

Table 42: Values of business model cube Vehicle (Model I: ITS-G5)

Appendix 10. VMP Model I: Value aggregations

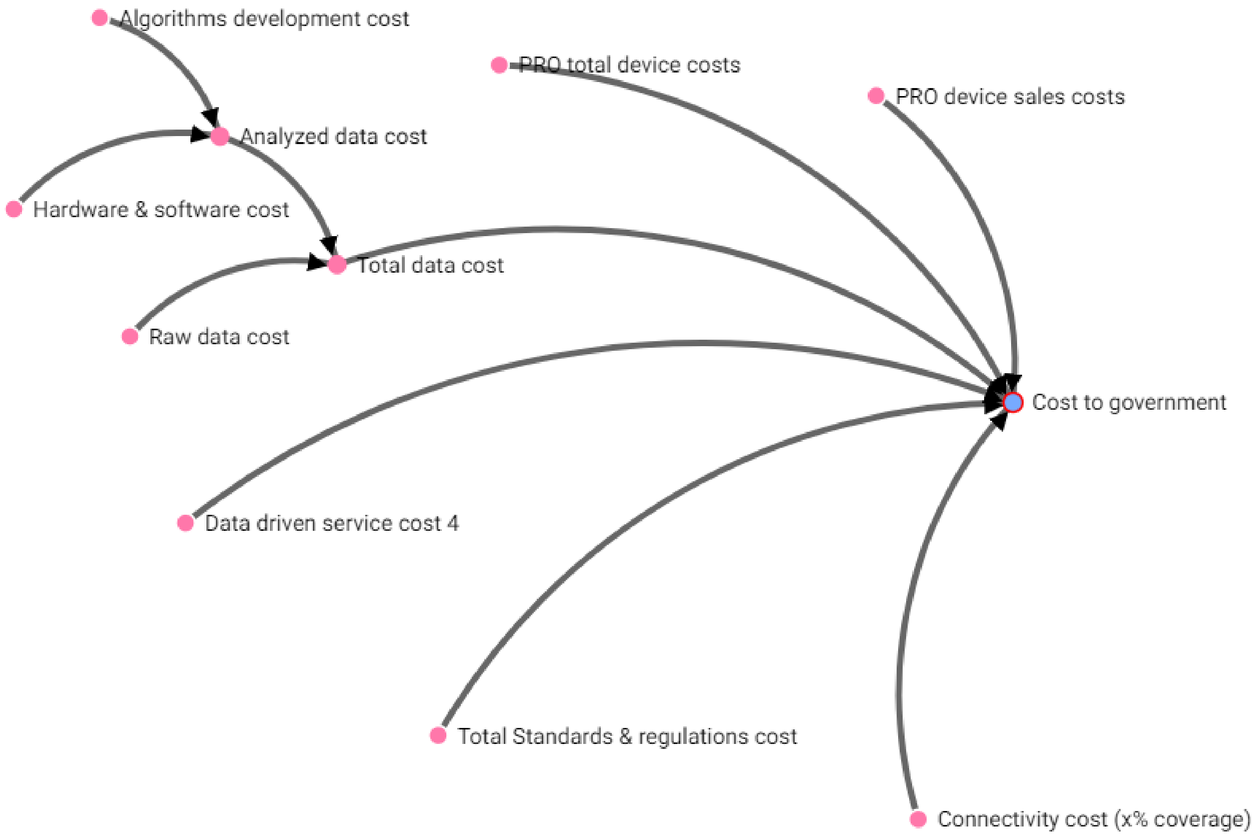

Figure 27: Value aggregation view of Plan value 'Cost to government'

The *Cost to government* is calculated as the sum of *PRO device sales costs*, *PRO total device costs*, *Total data cost*, *Data driven service cost*, *Total standards & regulations cost* and *Connectivity cost (x% coverage)*. Each of these is in its place the result of other values. We collapsed the *Total data cost* and see that it consists of the *Raw data cost* and the *Analyzed data cost*. The *Analyzed data cost* in its place is aggregated from the *Algorithms development cost* and the *Hardware & software cost*.

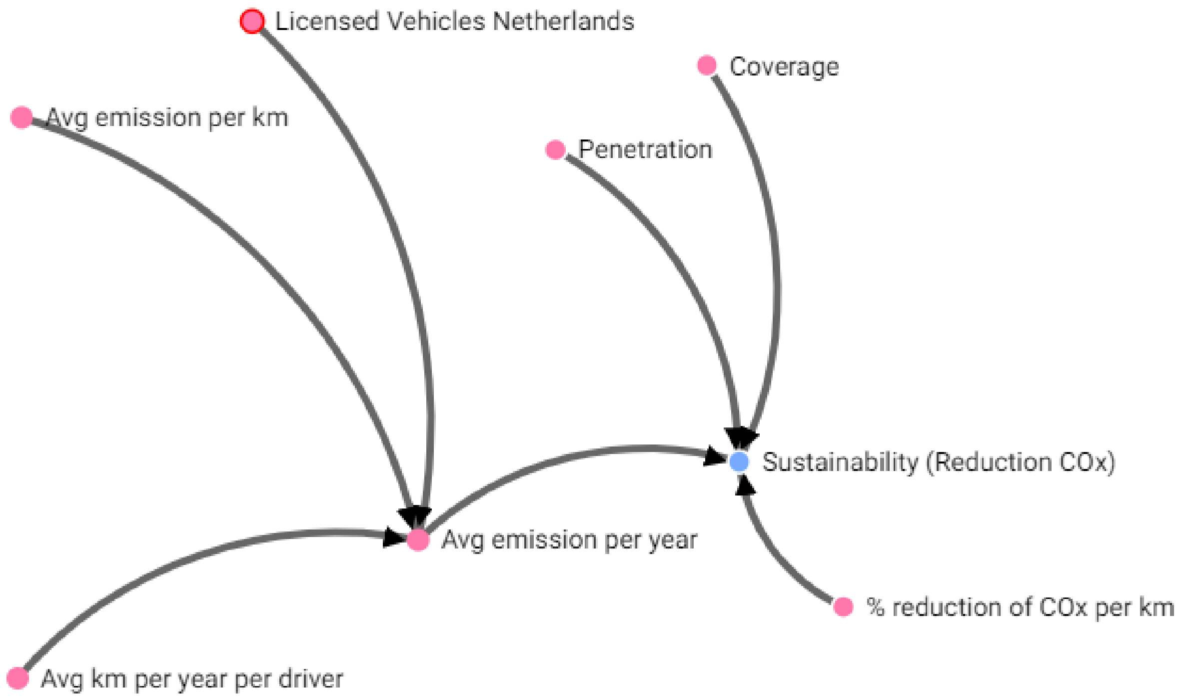

Figure 28: Value aggregation view of plan value 'Sustainability (Reduction COx)'

The *Sustainability (Reduction Cox)* is calculated as the product of *the %reduction of Cox per km*, *Coverage*, *Penetration* and *Avg emission per year*. The product of *Licensed Vehicles Netherlands*, *Avg emission per km* and *Avg km per year per driver* results in the *Avg emission per year*.

Appendix 11. VMP Model I: Plan value evolution over Phase 1 & 2

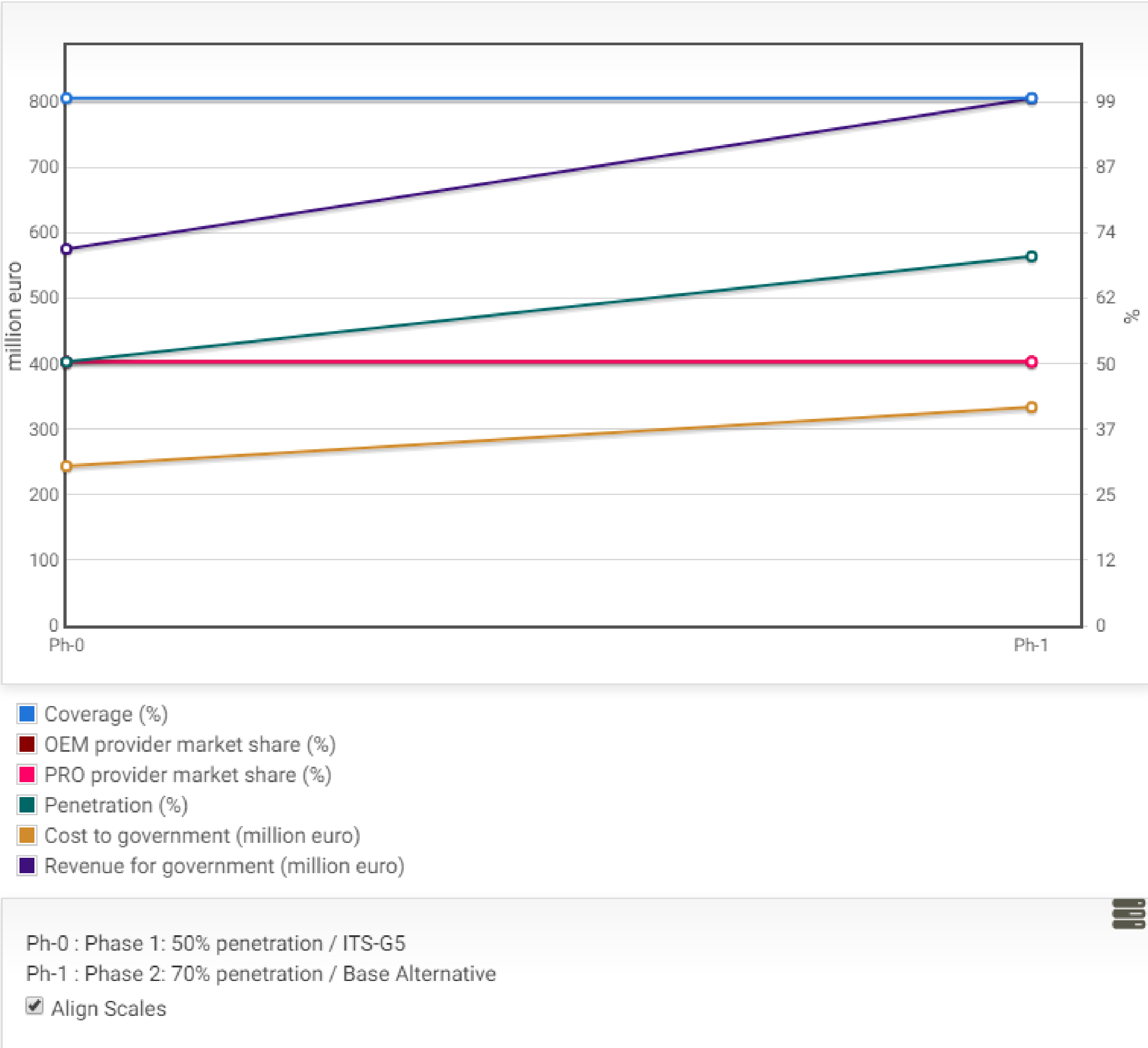

Figure 29: Graph overview of plan values (Ph-0 = 50% penetration, Ph-1 = 70% penetration)

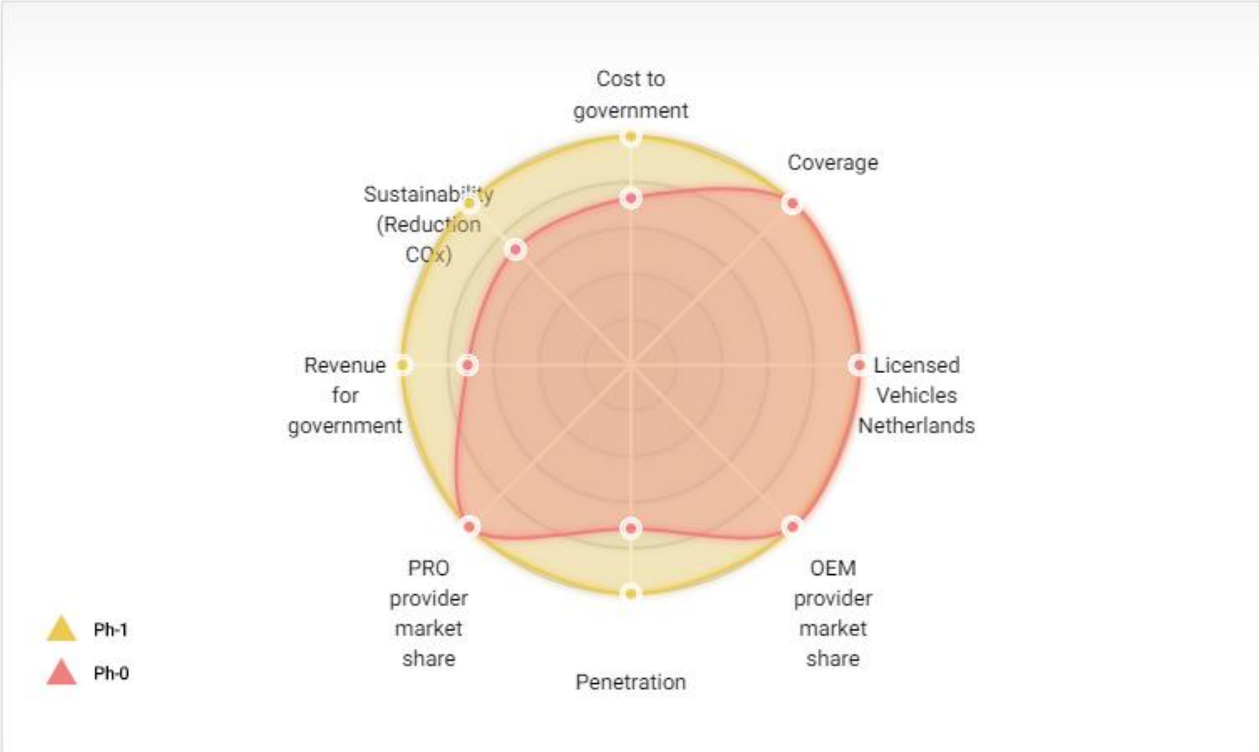

Figure 30: Radar overview of plan values (Ph-0 = 50% penetration, Ph-1 = 70% penetration)

Appendix 12. VMP Model II: Business model canvas

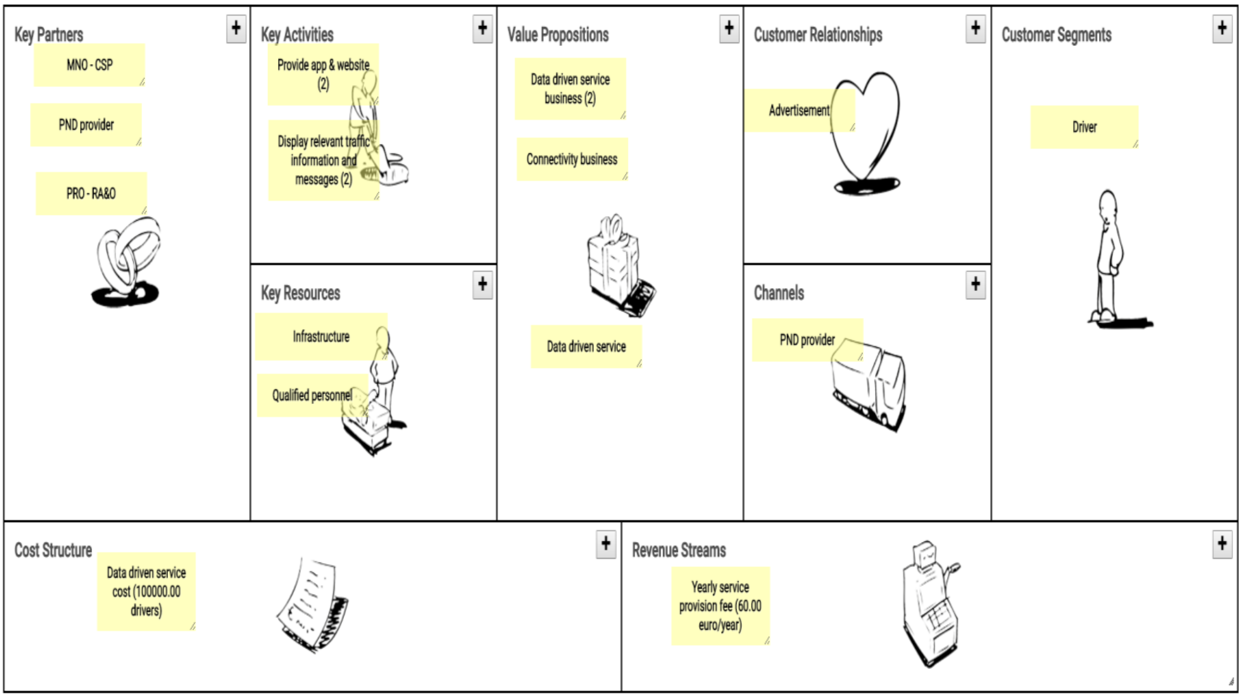

Figure 31: Business model canvas of PND provider (Model II)

Appendix 13. VMP Model II: Business ecosystem map

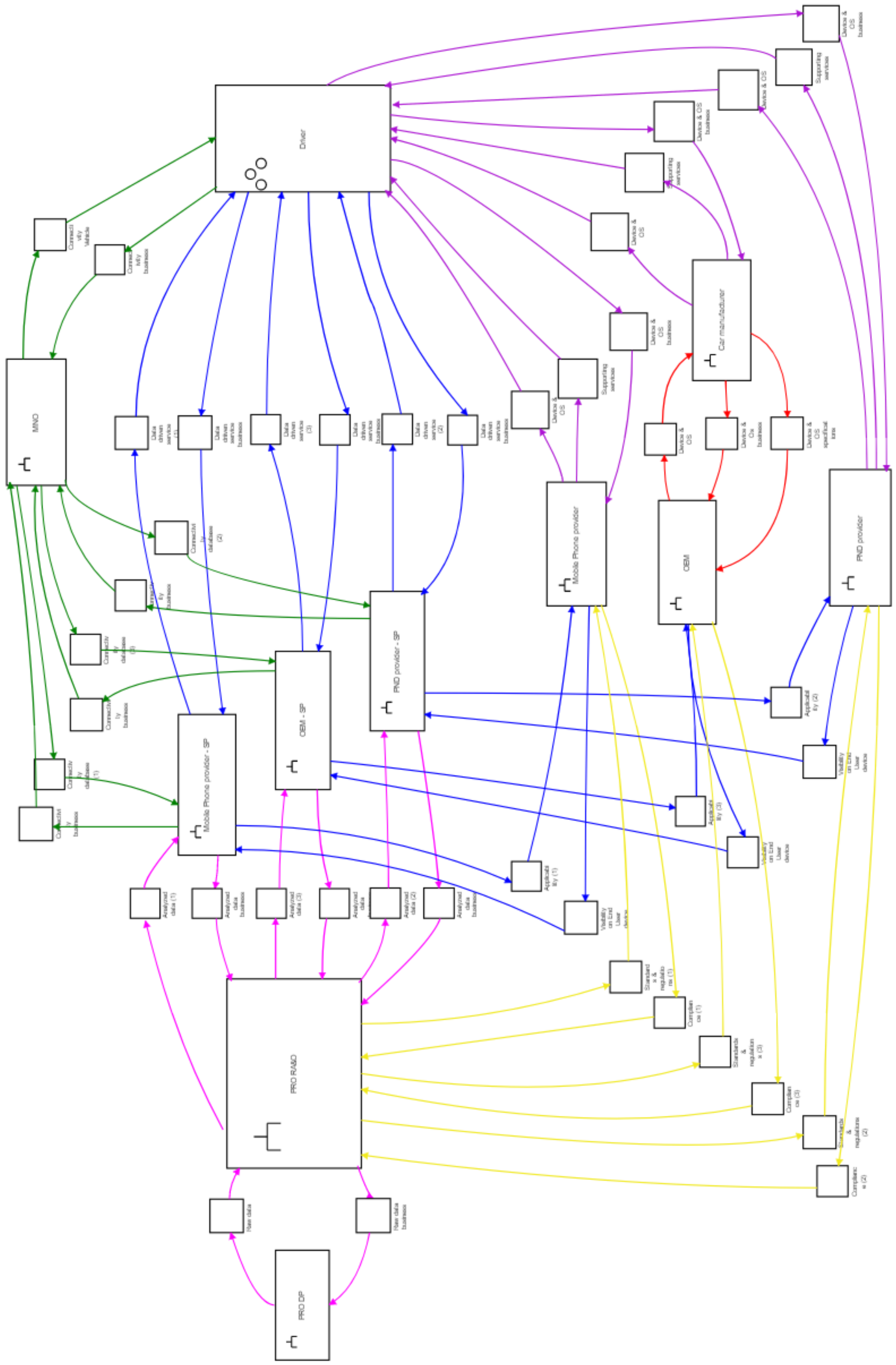

Figure 32: Business ecosystem map (Model II: 4G/5G)

Appendix 14. VMP Model II: Businesses and their business models

Business	Business Model
PRO - RA&O	Data
PRO - SP	IVS
OEM	Device OEM
Mobile phone provider	Device mobile phone
Mobile phone provider - SP	IVS Mobile phone
PND	Device PND
PND -SP	IVS PND provider
Car manufacturer	Vehicle
Car manufacturer – SP	IVS Car manufacturer
PRO - CSP	Connectivity

Table 43: Businesses and their business models according to Model II: 4G/5G

Appendix 15. Complementary use Damian and VMP

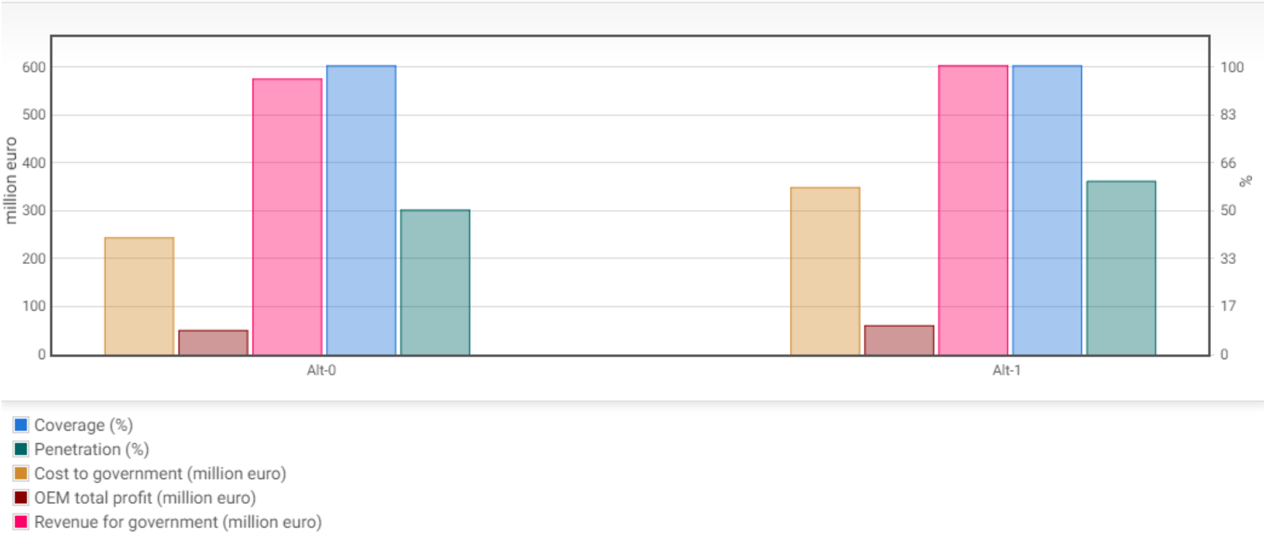

Figure 33: Graphic view of plan and business model values with Alt-0 = ITS-G-5, Alt-1 = ITS-G5: subsidized.

Values	Alt-0	Alt-1
Cost to government (million euro)	243.53	348.53
Coverage (%)	100	100
Licensed Vehicles Netherlands (million drivers)	10	10
OEM total profit (million euro)	50	60
Penetration (%)	50	60
Revenue for government (million euro)	575	603
Sustainability (Reduction COx) (Ton COx)	214	256.8
Total subsidies (x% penetration) (million euro/year)		120

Figure 34: Tabular view of plan and business model values with Alt-0 = ITS-G-5, Alt-1 = ITS-G5: subsidized