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Business Models for a Multimodal Traffic Management Ecosystem (MTME).

Subtitle: Business model development based on "Business Model Canvas" and "Value Network" methodology.

Handed in to
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1. Abstract

Traffic management focuses on ensuring safety, security, and efficiency across different modes of transport. Each mode of transport focuses on managing the traffic within their respective mode of transport. A Multimodal Traffic Management (MTM) approach will broaden scope and allow synchronised traffic management across different modes of transport such as road, rail, air, and sea. However, MTM is still at an early stage and needs to be analysed to have seamless integration within the existing transport ecosystem.

This study establishes a common understanding of multimodal traffic management concepts and solutions, within and across different modes of transport, for various stakeholders and multiple contexts. Under the context of this study, stakeholders are comprised of partners focussing on road, rail, sea, and air transport. This study supports in creating a balanced and resilient multimodal traffic management ecosystem by bridging gaps caused due to barriers and laying out benefits to individual actors. This study focuses on developing business models for both public and private actors, which could be combined through Public-Private Partnerships (PPP) to come up with a futuristic business model. The business models are developed in such a way that both private and public actors can adopt them in a seamless way, without causing critical damage to their daily operations. The business models are developed combining different methodologies such as “Business Model Canvas (BMC)”, “Value Network (VN)”. BMC helps in understanding a business from economic viewpoint and VN helps in assessing social and ecological benefits. When combined these two approaches we can have a business model that focuses on economic, social, and environmental benefit.

This study is developed within the framework of EU funded Horizon 2020 research and innovation project called “Orchestra”. The business models developed and discussed in this study are continuously evaluated by the project partners and is an ongoing process to achieve optimal business models for MTM.

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2. List of Abbreviations

Abbreviation	Full form
BMC	Business Model Canvas
CAV	Connected Autonomous Vehicle
COP	Community of Practitioners
CVP	Customer Value Proposition
ETA	Expected Time of Arrival
ITS	Intelligent Transport Solutions
KPI	Key Performance Indicator
MaaS	Mobility as a Service
MTME	Multimodal Traffic Management Ecosystem
PCS	Port Community Management Systems
PMA	Polycentric Multimodal Architecture
PPP	Public Private Partnership
STM	Sea Traffic Management
TMS	Traffic Management Systems
TTIS	Traffic and Travel Information Services
USP	Unique Selling Point
GHG	Green House Gas
EU	European Union
GDP	Gross Domestic Product
VN	Value Network
TO	Traffic Orchestrator
FO	Fleet Operator
TSP	Transport Service Provider
NU	Network User

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4. Introduction

Transport is an integral part of European Union (EU). It keeps economy moving and provides citizens a freedom to travel. Transport today accounts nearly 30% of the CO_2 emissions within the EU.(Martin Keim et al. 2021) However, transport also causes increase in fossil fuel consumption, traffic congestions, and collisions. In Germany (2021), drivers lost an average 40 hours due to congestion, and the average for the major cities is even higher, Munich (79 hours), Berlin (65 hours) and Hamburg (47 hours).(Bob Pishue 2021) Congestion cost the country 3.5 billion € or 371 € per driver.(Bob Pishue 2021) This implicitly explains the adverse impact caused by traffic on the citizens as well as on the economy.

The freight transport market is an important economic sector and has a massive impact on environment and society. In 2015, land freight transport represented 6% of European GDP. At least 75% (in terms of ton-km) of these freight operations were carried out by 4.2 million trucks on EU roads, 18% operations were carried out by railways with a fleet of 40,000 locomotives and 880,000 wagons, while inland waterways carried out 7% of operations having fleet of 15,000 barges.(‘30 by 2030. Rail Freight Strategy to Boost Modal Shift.’, n.d.) Freight transportation also contributes to road congestion especially in urban areas. In France, Great Britain and Germany, each driver wastes about 120 hours in traffic on average per annum.[1] It is projected that European land freight transport will grow by 30% by 2030. This clearly explains that traffic will increase in the forthcoming years and the dire need of seamless traffic management.

Studies suggest that a 10% decrease in journey times can boost productivity by 2.9% and that in highly congested regions, free flowing traffic could mean productivity gains of up to 30%. (European Court of Auditors 2019) It is imperative to reduce emissions to fight climate change, but the transport sector faces challenges in the fields of electrification, alternative fuels, digitalisation, and automation. These challenges can only be tackled through joint effort on all levels, be it EU institutions, Members States, local authorities, or communities. The European Green Deal is the political framework which was created to help in overcoming these challenges. It aims to make Europe climate neutral by 2050. New technologies can help in achieving this goal and support in staying align with the Green Deal objective.

[1] INRIX estimate = planning time + waiting time.

Multimodal transport is one way to deal with this situation. There are several benefits of multimodal transport such as: reduction in CO_2 emissions, reducing dependency on one stakeholder, shorter delivery deadlines, multiple business opportunities, efficient use of transport, improves traffic situation. Across Europe 6% waterway freight, 77% road traffic and 17% rail transport use multimodal services. (GEFCO 2022)

However, the multimodal transport in Europe is not the efficient one. There is lack in multimodal infrastructure. The situation differs from each member state for instance some countries are really moving forward and making developments in multimodal transportation. However certain countries like Austria, Spain, Belgium, France, and Spain are still lacking behind. (MAP Transport SA, n.d.) To be efficient multimodal freight transportation requires long distances, greater than 500 km. Yet in Europe, more than half of the freight transportation route is less than 50 km. (MAP Transport SA, n.d.)

This study focuses on an innovative digital traffic management approach which is designed to reduce traffic congestion and increase transport efficiency. Multimodal transportation will play an integral role in transportation for the forthcoming years. Multimodal refers to the combination of road, rail, sea, and air traffic networks in an integrated management approach. There is significant progress made towards competitive, resource-efficient, environmental, and user-friendly traffic management solution for each mode (road, sea, air, and rail) thus far, but an efficient and optimal utilisation of the whole transport network across all modes for users and operators still does not exist.

MTME can offer an optimal solution for seamless traffic management across all modes of transport keeping in mind both passenger and freight transport. Apart from daily operations, MTME can be helpful during calamity situations by aiding and cooperation to relief vehicles. To do so emphasis is laid on regional authorities such as transport authorities and municipalities to utilise MTME framework in their daily operations so that it can be optimised, and a rigorous framework can be developed. MTM is still being explored. There are not many companies operating in this domain. One can say that it is still in research and development phase and hence it becomes difficult to analyse its impact. There isn't sufficient quantitative and statistical data to support MTM. In order to get the accurate results this study focuses on two main research questions which are laid out as follows:

Research Question 1: Is there a sustainable business model possible for a Multimodal Traffic Management Ecosystem?

Research Question 2: Is MTM a profitable business sector?

This study is divided into five main sections i.e., Introduction, Background, Methodology, Results, Conclusions. Background section explores different theoretical concepts which are utilised in this study and gives a brief description of them so that readers can understand it in an easy manner. For instance, this study includes theory of Business Model Canvas, Value Network Methodology, triple bottom line approach. Background consists of summarized version of each theory and how their intended purpose is within the scope of this thesis. Methodology section involves using these theories alongside MTM. It explains in detail how BMC and Value Network are developed in affinity with MTM and furthermore explains its connection with triple bottom line approach. It dives deep and explains in a stepwise way how each BMC and VN diagram is developed and rational behind it. Results section includes observations and outputs achieved after implementing methodology. This section explains in detail the findings and outputs of the BMC and VN diagrams and draws inferences based on the results. Conclusions lay out the key takeaways for the readers and relevant information which could be beneficial to future research. The idea is that a reader should have a clear understanding of MTM and how it can be utilized in a positive way to enhance the transport network and benefit to the society.

5. Background

This section explains different methodologies which we are used in this study. First to identify the economical benefits of MTME I've considered BMC approach. This tool is easy to understand and gives detailed idea on the economic status of an organization. Once the economical advantages are obtained, the focus is then shifted to social and environmental benefits of MTME. It is evident in current times that a business should not only focus on economic benefits of stakeholders but must also consider environmental and societal benefits. To support this ideology, I've used Value Network methodology. Value Network methodology helps in understanding the intangible benefits which could be developed for all the stakeholders. These intangible benefits are labelled as ecological benefits and social benefits. Together when economic, environmental, and social benefits of a business models are collaborated, it formulates the triple bottom line approach. With the help of triple bottom line approach one can identify whether a particular organization practices sustainability within its organization and offer products/services which are sustainable in nature.

5.1 Business Model

The traces of business models can be traced back to fifteenth century, where they were used for a mechanical printing device which was invented at the time. But the scale and speed at which innovative business models are transforming industry landscapes today is unprecedented. Business model innovation is about creating value, for companies, customers, and society. The study of business models is relatively new, with much of the research published in the last decade. The popularity of the term is evidenced in a keyword search using the Google search engine and the ABI-Inform database. Results from these two sources indicated 4,326,812 and 2387 entries, respectively, for "business model".(Michael Morris, Minet Schindehutte, and Jeffrey Allen 2003) Despite getting this kind of attention there's no general definition for business model. Business models haven't been central focus of researchers. However, below are some definitions which are developed after detailed analysis.

"A business model describes the rationale of how an organization creates, delivers, and captures value."(Alexander Osterwalder and Yves Pigneur 2010)

"A business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable

competitive advantage in defined markets."(Michael Morris, Minet Schindehutte, and Jeffrey Allen 2003)

"A business model, consists of four interlocking elements that, taken together, create and deliver value. The four elements are Customer Value Proposition (CVP), Profit formula, Key resources, Key processes. The most important to get right, by far, is the CVP."(Mark W. Johnson, Clayton M. Christensen, and Henning Kagermann 2008)

The business models for MTME are developed based on Business Model Canvas (BMC). Through BMC we can integrate the traditional as well as modern age business models. In many industries BMC is preferred since it is simple, relevant, and easy to understand. With the help of BMC, we can easily integrate and develop the business models for public as well as freight transport. BMC considers various stakeholders such as traffic management companies, fleet operators, public authorities, IT companies, logistics companies.

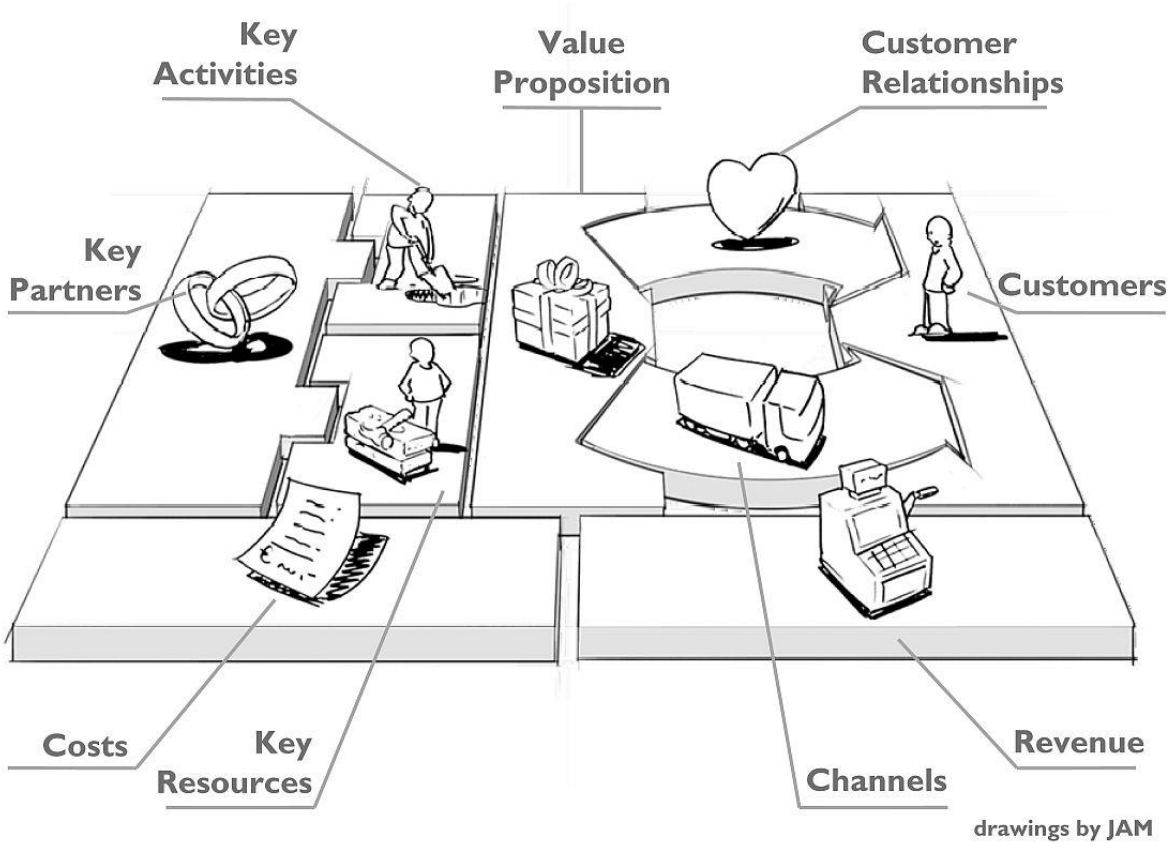

Figure 1 Business Model Canvas Layout. Source: Open Source

A business model can be best described through nine parameters that show the logic of how a company intends to make money. The parameters are discussed in detail accordingly:

Customer Segments: Customers could be an individual, group of people or organizations. However, it is critical for a business to identify which customers are they going to serve. Without profitable customers, no business can survive for long. To better satisfy the customers, they can be divided into segments such as: common needs, common behaviours, or other attributes. Accordingly, a business model can be designed serving specific customer needs. Some examples of customer segments are mass market, niche market, segmented, diversified.

Value Propositions: The product/service which are offered by the companies to satisfy customer needs, eventually generates value for the customers. If value is not served properly, customers tend to reach out to other suppliers to fulfil their needs. Values could be both qualitative as well as quantitative. Following could be the examples of value propositions: newness, performance, customization, brand/status, price, risk reduction, accessibility, convenience/usability.

Channels: Customer satisfaction is an integral part of any business. Channels are the means to achieve a positive customer experience. Channels are how a company communicates with its customers to deliver on its value proposition. Channels serves several purposes such as, raising awareness among customers regarding company's products and services, helping customers to evaluate a value proposition, providing post purchase customer support.(Alexander Osterwalder and Yves Pigneur 2010) There are several different types of channels such as direct, indirect, owned and partner channels. Owned channels can be direct, such as direct sales or sales through website. Partner channels are indirect and includes sales via wholesale distribution, retail, or partner-owned websites. Partner channels are prone to lower margins but allows company to expand its reach. Owned channels are expensive to setup and operate but attracts high margin. It is important to find the right mixture of channels to create a great customer experience and maximize revenues.

Customer Relationships: Customer relationships refer to the various types of relationships that a company develops with customer segments. It might be anything from intimate to automated. Customer acquisition, customer retention, and sales growth are some of the factors driving customer interactions.(Alexander Osterwalder and Yves Pigneur 2010) Several kinds of customer relationships may co-exist within a company, following are some examples: personal assistance, dedicated personal assistance, self-service, automated services, communities, co-creation.

Revenue Streams: A company must ask itself, for what value is each Customer Segment truly willing to pay?(Alexander Osterwalder and Yves Pigneur 2010) Revenue streams show how a business makes money from each consumer category. Onetime payment and recurring revenues could be considered widely accepted revenue streams. Each revenue stream may have a distinct pricing method, such as fixed, bargaining, auctioning, market-based, or volume-based pricing. Following are the general revenue streams: asset sales, usage fees, subscription fees, lending/renting/leasing, licensing, brokerage fees, advertising.

Key Resources: Key Resources are the assets required to make a business work. They allow businesses to create and offer a value proposition, reach target market, maintain relationship with customers and earn revenue. They can be physical, financial, intellectual, or human. They can be owned by the company or can be acquired from partners.

Key Activities: Key Activities comprises of important actions which a company must take to operate successfully. Key Activities differs based on the business model type. For instance, Key Activities for companies like Microsoft, Google includes software development. Whereas for companies like McKinsey, KPMG it includes problem solving. Key Activities can be categorized in following ways: production, problem solving, platform/network

Key Partnerships: Companies creates partnerships to extend their market reach, acquire resources or reduce risk. It comprises of network of suppliers and partners needed to make business model work. Companies tend to create partnerships for better allocation of resources. For instance, outsourcing helps a company to reduce their cost and it helps in developing a relationship with the supplier. Few companies focus on acquiring resources from the partner companies, for instance, mobile companies tend to acquire hardware from different manufacturers and procure software from alternate companies. In return this reduces the overall risk for mobile companies and allows them to build synergy with other companies.

Cost Structures: There are costs associated with creating and delivering value, maintaining customer relationships, and generating revenue. Naturally, the objective of every company is to minimize the costs. To do so, there are two main classes of cost structures: cost-driven and value driven.

Cost-driven business models focus on minimizing costs wherever possible. This is achieved through low price Value Propositions, maximum automation, and extensive outsourcing. For instance, Ryanair, EasyJet focuses on cost driven business model.

Value-driven business models are more inclined towards offering their value propositions. Here cost structure is not the focus. Premium Value Propositions and a high degree of personalized service drive this kind of business models. Luxury hotels are the perfect example for this category.

There are in general two kinds of cost structures:

Fixed costs: These costs remain same despite the volume of goods/services produced. Some of the examples are rents, salaries.

Variable costs: Costs that vary proportionally with the volume of goods or services produced are known as variable costs. For instance, flight tickets, their costs vary as the seat availability also their costs increase over weekends or festivals.

Together these nine building blocks forms the basis of Business Model Canvas.

5.2 Value Network Methodology

This study explores the value network methodology to better understand the business models and how these models could be made beneficial to all the stakeholders. I have followed the value network analysis developed by Verna Allee. This analysis was first developed in 1993 and since then has been used in several applications such as shop floor management, intangible asset management, business groups and economic regions. A value network is any set of roles and interactions in which people engage in both tangible and intangible exchanges to achieve economic or social good (Verna Allee 2008). There are two kinds of value networks internal and external. Internal value networks include interactions happening within the organization such as communication between research and development and sales department to achieve greater good for the company. Interaction among CEOs and CFOs to improve strategy. External value networks include interactions happening between organisations, suppliers, investors, business partners, customers. The idea here is to include all the stakeholders of the business ecosystem. External value networks tend to focus on benefits of all the stakeholders irrespective of whether it is economic or social. Below is an example of an external value network.

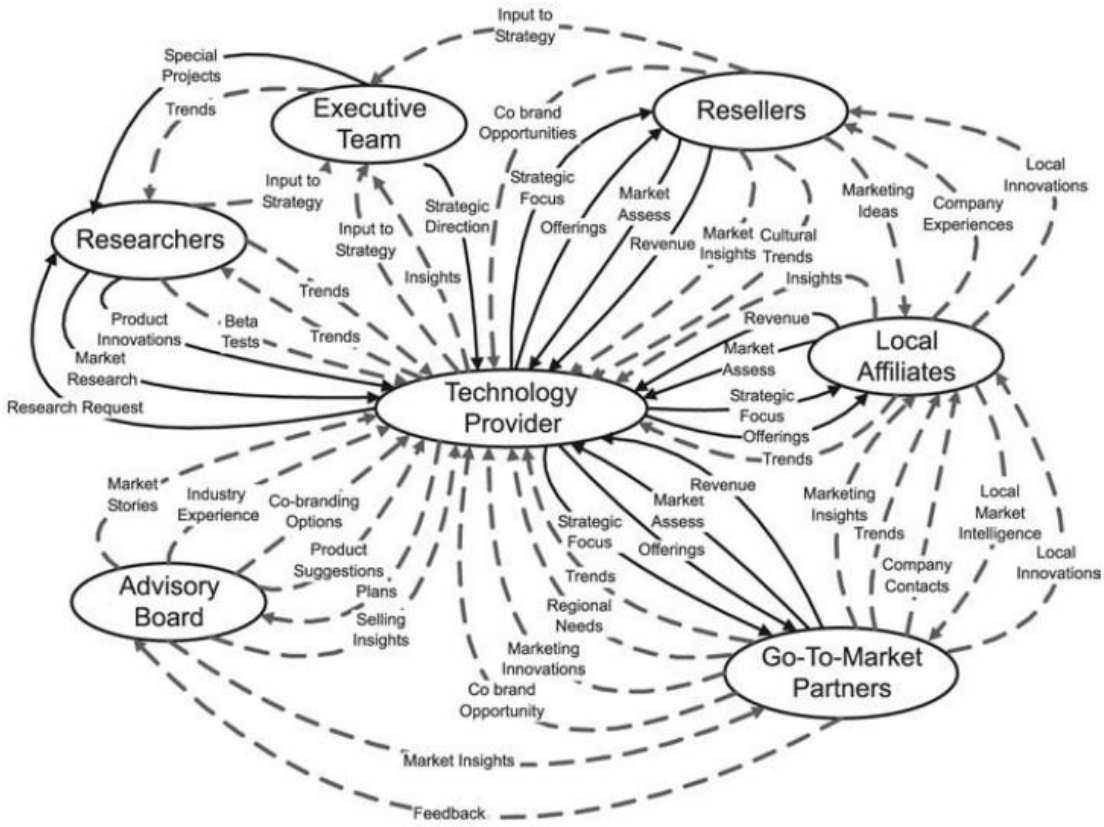

Figure 2 An external value network focusing on market innovation for a technology company. Source: Verna Allee, 2008

The mapping method consists of three simple elements, *Roles, Transactions and Deliverables.* Roles are denoted by circles; these are real people in the network who carry out business. In other words, they can be considered as stakeholders of the respective businesses. Transactions are the lines the lines going from one participant to another. The direction in which arrow is moving indicates the flow of transaction. The straight lines indicate the transaction of tangible assets whereas the dotted lines indicate transaction of intangible assets. For the simplicity of this study, we have considered only tangible assets. Deliverables are the actual things that are moving from one role to another. It can be knowledge, expertise, services, payment, feedback and so on.

Verna Allee explains concepts such as value conversion, value creation, impact analysis, tangible and intangible assets, internal and external facing value networks. However, the concept of value network analysis is relevant and sufficient for this study.

5.3 Triple bottom line approach

The triple bottom line is a business concept which mentions that firms should focus on their social and environmental impact apart from the traditional strategy which focuses only on profit. It can be broken down into 3 P's: Profit, People and Planet. The first component of triple bottom line is profit. Earlier a firm's strategic decisions revolved around generating profit and reducing costs and expenditure. However, in today's era businesses have power to bring effective change in the world along with making financial benefits. Apart from profit businesses should focus on sustainability as well. Many businesses have started giving priority to sustainability and it has been proven adopting sustainability initiatives to increase business success. Second component of triple bottom line is people. It is important to understand what kind of impact a business will have on the society. Traditionally companies laid focus on appealing to shareholders and it was a successful parameter for the company. In recent times companies have started focussing on creating value for all the stakeholders including customers, employees, and society. In today's era it has become imperative for a company, that their product/service should be beneficial to the entire society. The final component of this approach is planet. Every business should make strategic decisions to reduce their carbon emissions. The final pillar "planet" emphasizes that each company should take measures to reduce their carbon footprint. And many companies have implemented that by cutting down energy consumption, streamlining shipping practices, moving towards renewable energy sources.

Figure 3 Triple bottom line approach

MTME focusses on having triple bottom line approach. MTME not only focusses on generating profit from transport service providers, fleet operators, freight & logistics companies but also emphasises on collaborating with other actors of the society to minimise negative effects of traffic and help people to reduce their travel time and efficiently plan their journey. Not only

MTME promotes green transport but by efficient multimodal traffic management it can help transport and logistics companies in reducing their carbon footprint. MTME takes into consideration that stakeholder is benefitted out of this ecosystem and ensures technological, societal, and economic development.

6. Literature Review

Literature Review on Traffic Management, Multimodal Traffic Management, Traffic Management Ecosystems.

This section focuses on understanding the field of Multimodal Traffic Management (MTM) from an economical and business perspective. Here emphasis is laid on understanding the status quo in the field of MTM of freight as well as passenger transport. The objective of this section is to understand status quo and latest trends in the field of MTM, while keeping in mind factors such as economy, ecology, and sustainability. Hence the study considers scientific articles, research papers, audit reports, project deliverables and other relevant sources on MTM published within the time span of five years. By doing this the study limits and focuses only on the recent updates and transitions happening in the field of MTM. The relevant literature is identified based on extensive keyword-based research. The keywords which are most relevant to this study are, "Multimodal Traffic Management", "Traffic Management Ecosystems" "Integrated Traffic Management". However, there is limited scientific research being carried out around economic and business aspects of MTM. One can find plethora of scientific articles for traffic management solutions but majority of them focuses on technical development, simulations and are relevant to a particular mode of transport. Furthermore, it is difficult to identify economical and business-related information since MTM is still in its early stage and not many companies have adopted it in their existing business framework. As a solution to this issue, I've broadened the scope of literature with the help of following key words, "AI based business models", "Mobility Platforms", "Software-as-a-service", "Traffic Management". By doing this I could identify sources which are closely related to MTM. "Business Model Canvas", "Value Network Methodology", "Triple Bottom Line Approach" are some key words which could be closely related within the framework of this study.

Online platforms such as ResearchGate, Google Scholar, EU mobility data space, project deliverables, company and university library resources/files are used for finding most relevant literature sources. Apart from that with the help of expertise and support of project partners I was able to identify important literature sources. It is evident from the literature sources that MTM is a dominant topic of research. There are multiple research projects being carried out across Europe on the theme MTM. Hence to keep things simple, I've presented a summarised version of each research project which revolves around the topic of MTM. This should help

readers in getting acquainted with the status quo of MTM from an economic and business perspective.

Project Traffic Management Systems: Traffic congestion may have multiple sources such as bad weather conditions, construction zones, special events, poor transportation infrastructure. These bottlenecks are responsible for 40% of the overall traffic congestion, followed by traffic incidents, such as vehicle accidents with 25%, bad weather conditions with 15%, work zones with 10%, and poor traffic signal timing and special events with 5% each.(de Souza et al. 2017) Researchers (de Souza et. al.) introduces a Traffic Management System (TMS)[2] which can help resolving these bottlenecks. TMS collects the traffic related data from different sources such as vehicles, traffic lights, roadside sensors and then processes these data in a Traffic Management Centre (TMC) which in return helps in improving the overall traffic efficiency. There are two different types of communications taking place in TMS, one is V2V and the other one is V2I communication. To improve the overall traffic efficiency, TMS relies on three different parameters, information gathering, information processing and service delivery. Service delivery provides services to improve the overall traffic efficiency. Some of the services include congestion detection, avoidance, accident warning. The main shortcoming presented in this model is the availability of traffic data of the entire scenario. Since the data is not available from all the regions it becomes difficult for TMS to deliver accurate and precise information. Another shortcoming is data integration, the raw data which is received is difficult to integrate since there is no standardization. This leads way to a completely new scenario where we must deal with collecting the raw data and then integrating it requires extensive resources at hand. Finally, the raw data includes sensitive information from drivers and users and transmitting it may suffer attacks, hence a secure mechanism to protect this information is desired.

Artificial Intelligence (AI) could be an alternative to overcome above challenges. AI can help in making transportation systems smart and make way for new business models for digital platforms. Through AI we can detect current traffic flow along a particular corridor and adapt with required measures to overcome congestion. As more information is processed into the system, AI can develop patterns and provide preventive measures beforehand. Today drivers are guided by navigation systems to avoid traffic jams. However, these navigation systems have their limitations. AI can act as a gateway for intermodal transportation. Integrating of AI systems also leads to development of mobility cloud in the ecosystem. This will help mobility

[2] Traffic management systems are set of tools to improve overall traffic efficiency and safety in transportation.

players to integrate this mobility data in their business models. People must be kept at the centre of attention while designing business model of AI systems because acceptance and user trust are basic pre-requisite for a successful AI based business model.(Boll-Westermann et al. 2020)

Project Ultimate Traffic Management Systems: Rickard K. proposes a use case scenario of AI based system known as Ultimate Traffic Management (UTM) System which can be utilized at airports to manage the flow of human traffic through customs and boarding gates. It would also predict the traffic flow through a particular route at airport. These predictions are generated based on number of people checked in and head count obtained by the sensors. This would allow the airport management to deploy adequate staff at location. Other passengers could be redirected to avoid queuing. However, author believes the maximum potential of UTM can be achieved at international borders where congestion is major issue. UTM can be used for smooth management of cars and cargo vehicles at borders. Sensors can provide aforehand the exact number vehicles arriving at the borders and authorities can deploy staff accordingly. Furthermore, if governments implement facial recognition system in future, this feature can be integrated with UTM to verify identity of each driver which in return saves time of administration. Additionally, if heat sensors are installed in the infrastructure the system can immediately detect the presence of humans in cargo vehicles, this would ensure more accurate detection of human trafficking. A survey was conducted in Ireland which had responses of 700 residents and the findings were as followed: 73.4% favoured having smart traffic lights, 48.3% favoured having traffic apps to avoid congestion and reduce their travel time.(Kelley Rickard 2014) These numbers indicate that even residents are in favour of having digital platforms as a solution for traffic congestion.

More than three billion tons of goods were transported by trucks on German roads only in 2018.(Boll-Westermann et al. 2020) Energy consumption in the transport sector rose by 6.9 percent between 2005 and 2017, marking a significant impact on climate change.(Boll-Westermann et al. 2020) Digital platforms can also be advantageous to logistics industry. AI systems can help with route planning of all ships from one location. It would allow route optimization in real time, reducing delivery costs, improving delivery time, reducing layover times. For freight forwarders it can help planning of trucks well in advance.

Project Novorossiysk Sea Port: A case study analysis is carried out at Novorossiysk Sea Port, it discusses how the freight traffic affects traffic flow inside the port hub as well as to adjacent road network outside hub. There is no coordination in port hubs which results in increase in traffic inside and outside of the hub, performance of the hub is deteriorating and there is no

stability in the road network.[3] These bottlenecks are due to lack of strategic planning, poor integration of road network, lack of technological solutions, inefficient port traffic management.(Viacheslav Fialkin and Elena Veremeenko 2016) After implementing a traffic coordination system, it was observed freight traffic could be managed in a better way, also it gave stability to other road networks outside the hub. Via implementation of simulation model researchers were able to forecast handling time of each vehicle and made relevant recommendations for vehicles which eventually resulted in seamless operations. Following were the key observations from the simulation modelling:

(1) reduction of vehicle handling time by 16% without provision of supplementary service facilities and

(2) increase of the number of vehicles handled by 35% per 24 hours.(Viacheslav Fialkin and Elena Veremeenko 2016)

Implementation of simulation modelling helps in better management of traffic flow inside seaport. Moreover, it also affects in better traffic flow for outside and adjacent road networks. It can also be stated that a non-conventional approach needs to be used for resolving traffic related bottlenecks.

Project National Single Window: Countries such as Germany, France, UK have implemented Port Community Management Systems (PCS). PCS is a platform that allows secured exchange of information between public and private stakeholders involved in cargo management of ports. PCS is seen as local body which offers information on tracking, tracing for local port authorities. However, PCS are not useful when we consider entire European continent. Since they do not serve the cross-border operating functionality. To address this inefficiency concept National Single Window (NSW) is developed. Researcher Mihai-Cosmin Niculescu and Marius Minea developed NSW to integrate maritime waterway transport with other modes of transport and with PCS. NSW acts as a single point of contact for sharing freight related information between public and private stakeholders from different transport modes for all EU Member states. Some of the functionalities of NSW are ships arrival and departure notification from ports of Member States, scheduling, booking, shipment tracking, calculating ETA, road status,

[3] Viacheslav Fialkin and Elena Veremeenko, 'Characteristics of Traffic Flow Management in Multimodal Transport Hub (by the Example of the Seaport)', *Elsevier B.V*, 28 September 2016, 7, https://doi.org/doi: 10.1016/j.trpro.2017.01.053.

weather reports.(Mihai-Cosmin Niculescu and Marius Minea 2016) The figure attached below shows the detailed concept of NSW.

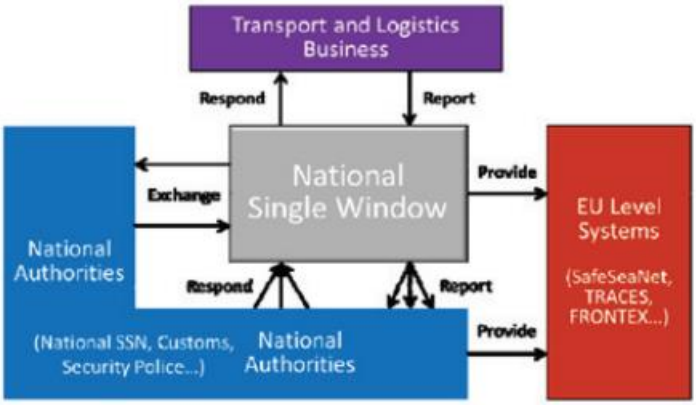

Figure 4 Concept of National Single Window (Source: Niculescu et.al)

From a legal and technical perspective NSW helps in addressing the shortcoming of port authorities however since this solution is still not implemented at ground level there are many unanswered questions. For instance, we need to understand the economic and political impacts which comes along with this solution. From business perspective we need to understand, how can we make NSW into a profitable business. What is the response of private stakeholders towards such digital platforms?

Numerous projects are being carried out across EU on tackling traffic management with the help of multimodal transportation. These projects have shown that they can have a positive impact on traffic safety(up to 11% fewer accidents with injuries in bad weather conditions), mobility (up to 20% shorter travel times) and environment (up to 10% less energy consumption with corresponding effects on CO_2 emissions). (Enrico Ferrante, Autovie Venete, and Orestis Giamarelos 2021)

Project TTIS (Traffic and Travel Information Services): is one such project which focuses on having a seamless travel and traffic information for entire road network of the Europe. The platform offers information related to forecast, speed limit, road weather conditions, multimodal travel information. This digital platform addresses multimodal traffic and travel information as one of its services and unfortunately there came no profitable business model out of it. Nevertheless, researchers associated with this project highlighted some aspects which are relevant from an economic and business standpoint. When it comes to traffic related information it is not clear who will be responsible for sharing of information to the users. For

instance, if national/public authorities are responsible for sharing the information following could be the possible effects:

- Public authorities are under obligation to provide traffic related information free of cost because it contains information which is necessary to all the users.
- Reducing traffic congestion is a part of transport policy for almost all countries and keeping that in mind it becomes imperative to achieve the policy goal rather than making business out of it.
- Service continuity and harmony to society is the primary objective when a service is offered by public authority.

So, a feasible business model could be developed when a private entity offers value added service on top of this digital platform. Researchers of this project believe that a basic service is likely to be available as free of charge like traffic information like provided by Google Maps as of now. To make such venture work, a public private partnership is recommended where public authorities take in charge of handling all the data processing and private entities focuses on offering services and making business out of it. A binding contract and a service level agreement must be established when private entities are processing/accessing the data from users.

Project MONALISA: EU funded projects like MONALISA and MONALISA 2.0 introduces a concept called sea traffic management. The overall goal of sea traffic management (STM) is to make sea transportation efficient, safe, and environmentally sustainable. STM is a concept which is based on sharing secure, relevant, and timely information among authorised personnel, users. It is expected that STM will improve the daily operations via providing predictability of arrivals and departures, reduced accidents, optimised route selection, reduced traffic congestions, alerting vessel ships of the delay in loading/unloading. STM aims to maintain interaction between the maritime stakeholders and port authorities with a minimal impact on the environment. Researchers claim that sea traffic efficiency and port efficiency can be improved if information sharing is transparent among all the actors involved. MONALISA 2.0 conducted real life tests in Port of Gothenburg and Port of Valencia and there were positive results such as shipping traffic was minimised in environmentally sensitive areas, optimised route distance, improved synergy among the ports. The cost benefit analysis shows that reduction in distance for making route optimisation is profitable by 0.2% (Mikael Lind et al. 2016). STM can be utilised as a gateway to multimodal transportation, STM can communicate with actors'

other modes of transport to better manage the traffic going in and out of the port. Researchers claim that with the right usage of STM shipping companies as well as port operators can reduce their operational expenses and offer better services to end consumers.

Project Traffic Management as a Service (TMaaS): is an economical, flexible, and cloud-based solution for urban mobility management. It offers a management dashboard for traffic planners and local authorities, to better manage the mobility systems and a mobile app for citizens' which will alert users in the event of disruptions or accidents. Existing traffic management solutions are high-end, complicated, and expensive which meet the needs of metropolitan cities. These solutions overshoot the requirements and budgets of smaller and medium cities. The objective of TMaaS is that cities can access mobility related data in real time using existing data sources and not investing heavily in infrastructure hardware. Authorities gets access to data related to public transit schedules, bike count, floating car data, air quality information, etc. Project TMaaS does not cover the entire scope of MTM. It is limited to road network and its users. There is no scope of freight and logistics traffic management in this project. However, there are certain aspects of this project which can draw inferences when it comes to MTM. For instance, the main stakeholders for TMaaS and MTM are most likely to remain same which are citizens, tourists, local transport service providers, local authorities, policy makers, citizens' representatives, mobility experts, ITS experts and transport authorities. The project methodology included interviewing experts in the field of traffic management and these experts questioned the benefits of traffic management/potential negative consequences for example, (Delphine Grandsart et al. 2020)

1. Improved traffic information may encourage cars to avoid congested regions by taking other routes through residential areas or school zones.
2. Governance issues such as project ownership, cooperation among departments and external partners.

These concerns should be addressed when creating an organisational framework of MTME.

Project OPTIMA: Traffic Management in railways is still done in silos. Each Infrastructure Manager is responsible for managing traffic in their respective region. Each EU country have their own Traffic Management Systems (TMS). These systems are not fully interconnected with all the stakeholders and hence the efficiency of these systems is limited. For example, signalling each Infrastructure Manager has their own system of signalling which is not compatible to other signalling systems. As a result, there is an

unnecessary delay which trains needs to face throughout their journey. Project OPTIMA focuses on developing an communication platform where all these TMS can interact with each other and improve the overall traffic efficiency across rail network.(Gabriele Cecchetti et al. 2021) The project also ensures to have this platform having standardised interfaces such as data structures, communication protocols suggested by European Rail Traffic Management System (ERTMS). In the long run, OPTIMA also aim to incorporate TMS functionality for freight companies so that all the stakeholders of the rail ecosystem can be benefited through this platform. However, this project is still going on and there haven't been published analysis from an economical and business perspectives.

(Mohamed El moufid et al. 2019) proposed a system which focused on increasing multimodal transportation in urban areas. Here they considered private transport such as cars and public transport such as trams, trains, buses, etc. It is important to note that their system focussed on road and rail network. To complete the entire journey, the users switched from private transport to public transport and to do so they had to first find parking space to leave their cars and then continue their journey via using public/shared transport. Hence it can be said that finding the right parking spots for private vehicles is an important aspect of multimodal transportation. Once that is achieved only then a user can be convinced to switch their mode of transport. Furthermore, there are some important parameters which a user will consider while making multimodal transit such as:

- Minimum cost required to complete the journey.
- Total duration of travel.
- Preference for a particular mode of transport.
- Degree flexibility while switching among the modes of transport.

Ranking of these parameters could vary depending on the individual users. But they are critical for multimodal travel planning.

Project Traffic Management 2.0 (TM2.0): is a concept which focuses on interactive traffic management. This is done by combining data from public authorities, road operators and from mobility services in vehicles and smartphones. In TM2.0 data from road operators is provided to mobility service providers and from thereon they provide tailor made traffic related information to their customers. The future of traffic management is to combine intelligently the individual driver objectives together with network wide management strategies (Laura Coconea et al. 2019). TM2.0 aims to incorporate multi-modal, seamless, flexible, user-friendly, all inclusive, price-worthy, and environmentally sustainable travelling options. Even though TM2.0 focuses on multimodality, it is still limited to road network and doesn't include air and

sea transport mode. Furthermore, it is an ongoing research project which has limited information on economic repercussions.

Big Data is a critical aspect of MTM. Integration of big data into traffic management is at an early stage. So far big data is only collected from road networks and motorized vehicles. In order to make MTM efficient, we need to gather big data from different modes of transport such as air, rail, sea and road. Researchers (Ivana Semanjski, Sidharta Gautama, and Flanders Make 2018) proposed challenges which comes along with implementation of big data based traffic management. Multimodality becomes a challenge when different transport modes need to be operated in under one framework. Integrating different datasets from different authorities and companies is a challenging task and there is a need to have proper data quality standards for its maintenance. This generates the need to have proper licensing, data access, privacy, and processing framework. Regional and national governance must also work in a collaborative environment to have a seamless MTM.

However, these challenges create a space to improve future traffic management framework. Some trends according to researchers (Ivana Semanjski, Sidharta Gautama, and Flanders Make 2018) which could be seen in near future will have best traffic management practices across different modes of transportation, strategies focussing on rewarding sustainable mobility behaviour for e.g., German government offering nationwide public transport ticket for 9€, is a rewarding strategy for citizens to use more of public transport in their daily life. Having a unified multisource data for entire mobility ecosystem which ease up the integration of CAVs and provides real time data for better traffic management purposes. The establishment of new business models with AI for existing and new providers of mobility services is also supported by the gradual development of a mobility cloud in conjunction with a data ecosystem.(Sussane Boll-Westermann 2020) For optimized transport planning, the framework conditions must ensure, that mobility data is made available to the public sector for overarching (state) transport route planning.(Sussane Boll-Westermann 2020) This will allow transport authorities to create flexible solutions without vendor lock-ins. Many a times a new solution is not a feasible option because the switching cost is extremely high, and cities cannot afford it and are forced to use the services of existing vendors. Thus, authorities should focus on implementing flexible solutions which does not create dependency on one single vendor. However car drivers may not be interested in such framework/algorithms that determine traffic information on roadside signage, but in travel time reduction that they may realize by any means of traffic management.(Paul Grefen et al. 2017)

7. Methodology

The literature review section highlights that multimodal traffic management could be achieved by the help of digital solutions. There are many platforms and simulations model under research to make the multimodal traffic management a feasible option. However, there is a lack of research being carried out on how to integrate these digital platforms into the existing business model of public transport and freight companies. It is critical for public transport companies and freight companies not only to use these digital platforms but also to make revenue out of it.

To begin with we need to understand what are the existing business models for both public transport and freight companies? This will help us in understanding the status quo of existing business models. In the results section I've listed out business model of public transport companies and freight companies. These models will give a general understanding to the readers regarding the public transport and freight businesses. Under freight transportation we have developed a unified business model for rail freight, air freight, sea freight and last mile delivery companies.

Based on the information generated from business models we can identify what are the similarities and the differences in the business models of public transport and freight companies. This gives us an opportunity on how to integrate MTME in both areas.

The first step of the methodology involved creating a general BMC for passenger as well as freight transport companies. Moving ahead the focus is laid on integrating MTM in the existing business of companies. Accordingly, a unified version of BMC is created which showcases how a traditional BMC of passenger and freight company would look like once they've integrated with MTM platform. The unified version of BMC is created with the help of project deliverables such as (Ludovic Vaillant et al. 2021). The results and observations are discussed at the later stage. The unified BMC is also presented and verified by the research partners who are experts in the domain of multimodal transportation and traffic management. This step is performed since this study is developed within the framework of EU funded research project "Orchestra".

The second step involves laying out BMC of Traffic Orchestrator (TO) since this will be an entity/body which will perform MTM services. Based on the project deliverables (Ludovic Vaillant et al. 2021), (Marit K. Natvig et al. 2022) an initial version of BMC for TO is developed. This canvas lists out important parameters such as key partners, customers, revenue streams, cost structures and value propositions. This initial version of BMC for TO is also

reviewed by traffic management experts and project partners. Readers can find the final version of BMC of TO in the results section. Important details and observations are discussed in results section.

The Business Model Canvas however shows only the economic aspects of the business. However, to be successful, it is critical for Multimodal Traffic Management to be beneficial to society and environment as well. To further support this methodology the study considers Value Network methodology to understand how all the stakeholders can be benefitted via MTM. Value network methodology is not something new to mobility field. Many researchers have utilized this method, for instance (Trond Foss, 2017) describes the importance of value networks for ITS services and how value networks should become part of ITS services. His paper describes business models and value networks are often interconnected and value networks can be used to for impact assessment as well. Furthermore, value network is a relevant instrument for the stakeholders to develop their own business model if they are expected to be part of the value network offering products, services and /or information. (Trond Foss, 2017)

As mentioned in the background section here we have used Verna Allee value network methodology. The detailed explanation of how this methodology is developed is explained earlier. For the simplicity of understanding we have categorized the interactions happening among stakeholders in three distinct categories. The black line indicates economical, green line indicates environmental and yellow line indicates societal interactions. Initially we have plotted interactions happening among individual stakeholders and then merging rest others to create a big picture. This study focuses on four main key stakeholders' type, Traffic Orchestrators (TO), Transport Service Providers (TSP), Fleet Operators (FO) and Network Users (NU). These stakeholders are formulated by researchers (Marit K. Natvig et al. 2022) for the project deliverable titled, "Initial use cases for multimodal traffic management". This document acts as a reference point for value network methodology. The definitions of these stakeholders are as follows:

Traffic Orchestrator (TO): Traffic Orchestrator manages the traffic across different modes of transport. They are responsible for MTM. Their aim is to arrange for sustainable transport from an environmental, economic/socio-economic, and societal point of view. (Marit K. Natvig et al. 2022)

Transport Service Provider (TSP): Transport Service Provider orchestrates transports requested by Transport Users. A Transport Service Provider could also be a Fleet Operator operating own vehicles, MaaS service provider or a public transport operator.

Fleet Operator (FO): Fleet Operators owns the fleet of vehicles and offer services to TSP and NU. They carry out transport operations as demanded by TSPs and NUs. Their operations are planned, and TSP and NU are informed about the progress as and when required. FO can offer services to passenger transport as well as to freight transport.

Network User (NU): Network User could be a pedestrian, Micromobility user or a system such as: CAV. Network Users are dependent on TSPs, FOs and TOs to complete their journey. NU share their real time data so that other stakeholders can have glimpse of real time traffic situation and plan their operations accordingly.

There are several other small stakeholders who affect the MTM business. However, defining all of stakeholders is not the scope of this study but readers should be able to interpret their meaning based on the supporting information provided as per VN diagram.

The value network diagrams developed in this study will revolve around above mentioned four key stakeholders. In results section one can find the value network diagram between the TO and TSP. Initially I have developed value network diagrams on one-to-one basis and once that part is done, I have merged all the diagrams and combined them to form a single value network which includes all the relevant stakeholders of MTM.

The idea is to create different kind of combinations of VN diagrams so that one can identify different kind of interactions/exchanges taking place among the stakeholders. Eventually the idea is to combine all the stakeholders to create a single VN diagram. This will show us different kind of interactions happening among the stakeholders simultaneously. Since I've divided the interactions happening in three subcategories like economical, ecological, and social. This gives us a highlighted view of interactions/exchanges taking place from economic, social, and environmental standpoint. Eventually this can help us in business model assessment. In this way the business models developed follows the framework of sustainability and fulfils triple bottom line approach.

The VN diagrams are developed with the help of online tool known as "draw.io". It's an open-source tool and is available as a desktop version. It's an easy-to-use tool and consists of multiple options which could be useful when dealing with diagrams, charts, and figures.

8. Results

The objective of the study is to develop the business models for MTME. The business models need to be designed in such a way that it becomes easy for public and freight transport companies to integrate the MTME platform in their existing framework.

The reader can find different versions of BMCs as shown below. Figure 5 discusses the BMC of passenger transport companies utilizing MTM in their daily operations. Initially a unified BMC representing passenger transport companies is developed. This general BMC for passenger transport is developed considering annual reports and business models of various transport operators such as Deutsche Bahn, Uber, DB Regio, S-Bahn Berlin, BVG. Once a generalized BMC is developed for passenger transport companies, with the help of insights achieved from literature review section and other project deliverables, specific parameters with green background are inserted in this BMC. These highlighted parameters indicate the value addition caused by MTM. As a result, when passenger transport companies start utilizing MTM solutions following could be additional value propositions which they can offer to their customers. These value propositions are as follows: improved efficiency, seamless operations in the vent of disaster/abruptions/accidents, better data security, real time information to travellers about major disruptions, vehicles running at optimal capacity. However, this would lead companies to increase their cost structure. Since acquiring services like MTM will come at a cost. Consider it to be a service cost needed to use MTM services. This kind of digital traffic management platform will also become a key resource for passenger transport companies. Moreover, with it helps the activities will improve to better assistance in terms of fleet management, planning and scheduling. And the entity offering these services will tend to be a key partner in the long run.

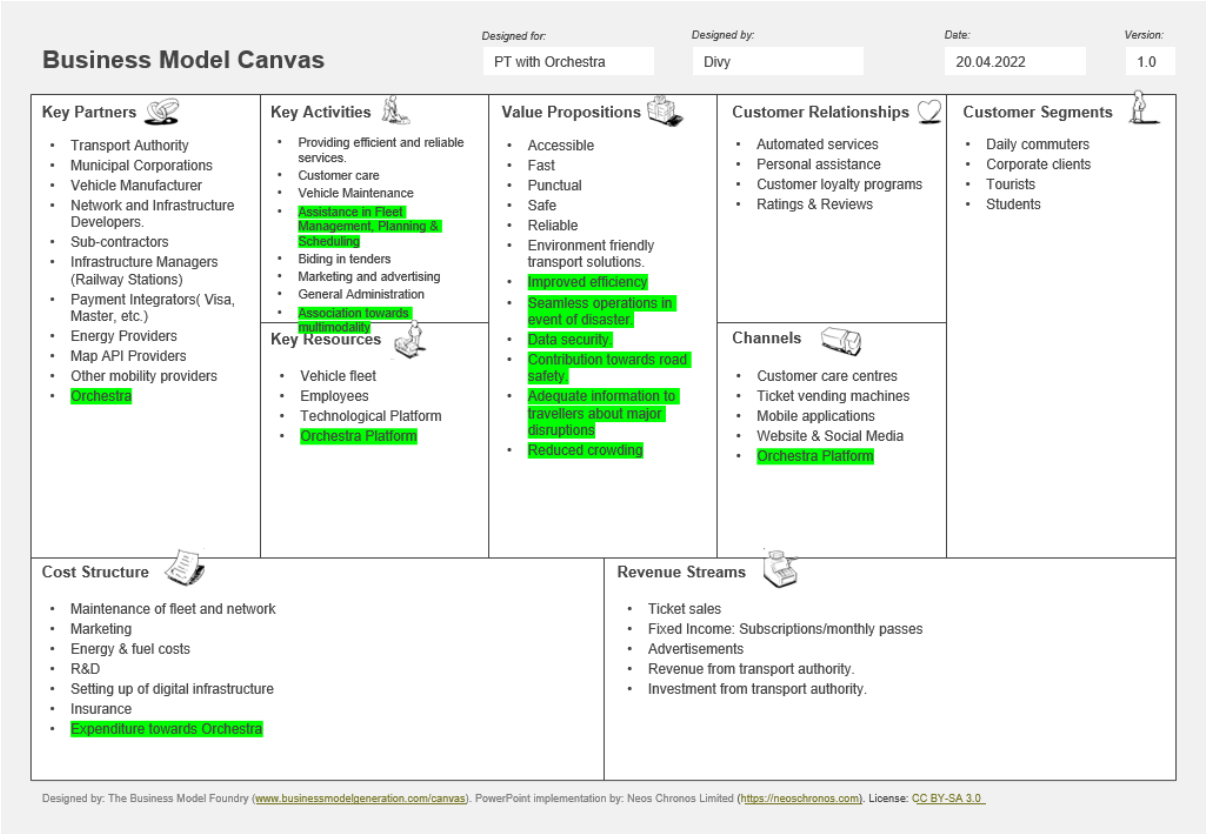

Figure 5 BMC of passenger transport using MTM. Source: Own creation

Similarly Figure 6 indicates a generalized BMC for freight and logistics companies. In order to develop this generalized BMC for freight and logistics, I've taken into consideration business models/internal report/audit reports of entities such as DB Schenker, Maersk, in city logistics companies, start-ups in the field of last mile delivery. The parameters which are highlighted in green indicates the value addition caused by using the services of MTM. As a result, freight and logistics companies can offer their customer improved efficiency, data security to each party, contribute towards road safety, better monitoring, planning, and management. Companies might need to incur initial costs to utilise MTM services. However, they can have huge return of investment (ROI) since they can offer multimodal services to their customers, give better assistance and planning and scheduling support.

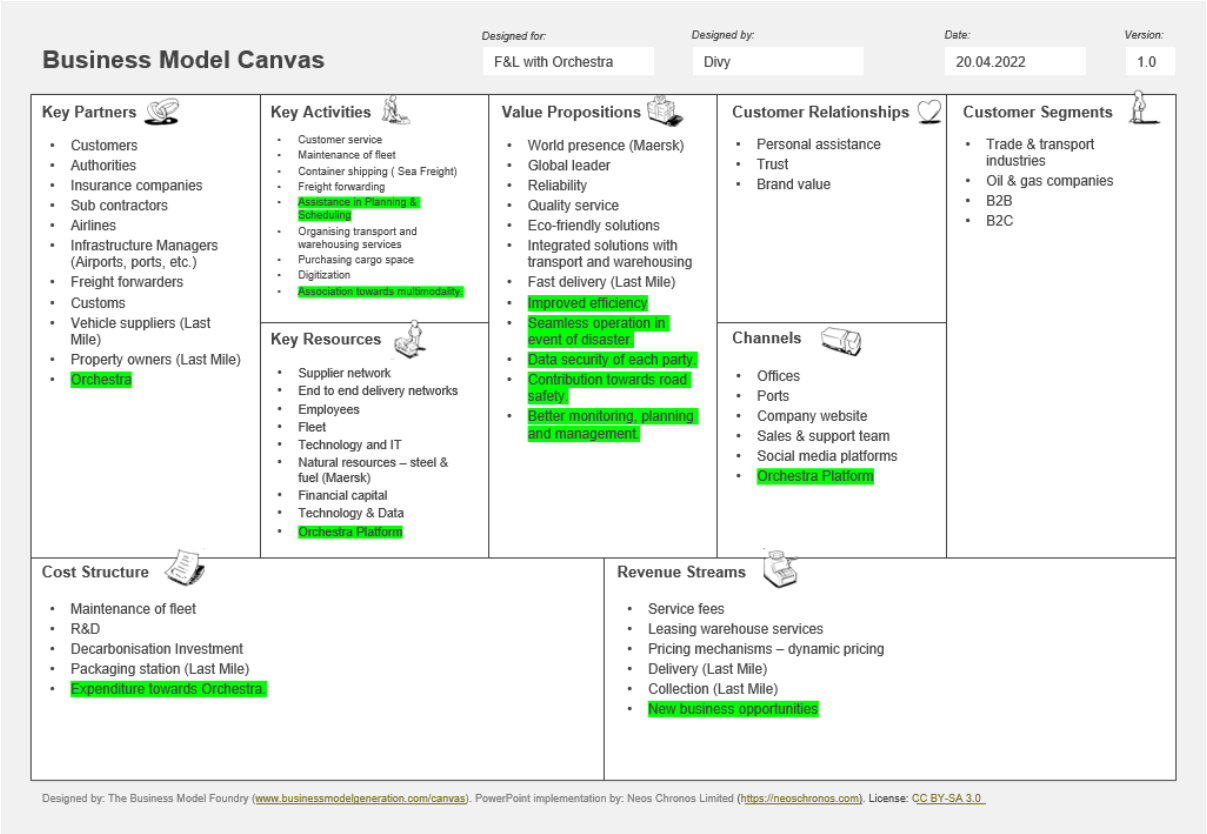

Figure 6 BMC of freight & logistics using MTM. Source: Own Creation.

Figure 7 indicates the general BMC of MaaS aggregator using MTM in their daily operations. MTM is a key benefit for companies involved in MaaS domain. Since they're already working along side multimodal transportation, they can closely relate to the challenges which comes along with multimodality. Since MaaS is still at its early stage we can consider that they could be the early adopters of MTM solutions. It is quite difficult for big corporations to revise their business models since it can hamper their daily business. On the contrary MaaS aggregators can easily adopt MTM solutions since doing so wouldn't cause them a big damage in long run. They can easily recover the losses incurred by offering more efficient multimodal transportation services. MTME can also give them a flexibility in choosing the contractors and service providers. In case, if a particular transport service provider is not available with the help of MTM they can switch their customers to different service provider or mode of transport. This beneficial to both aggregators as well as commuters.

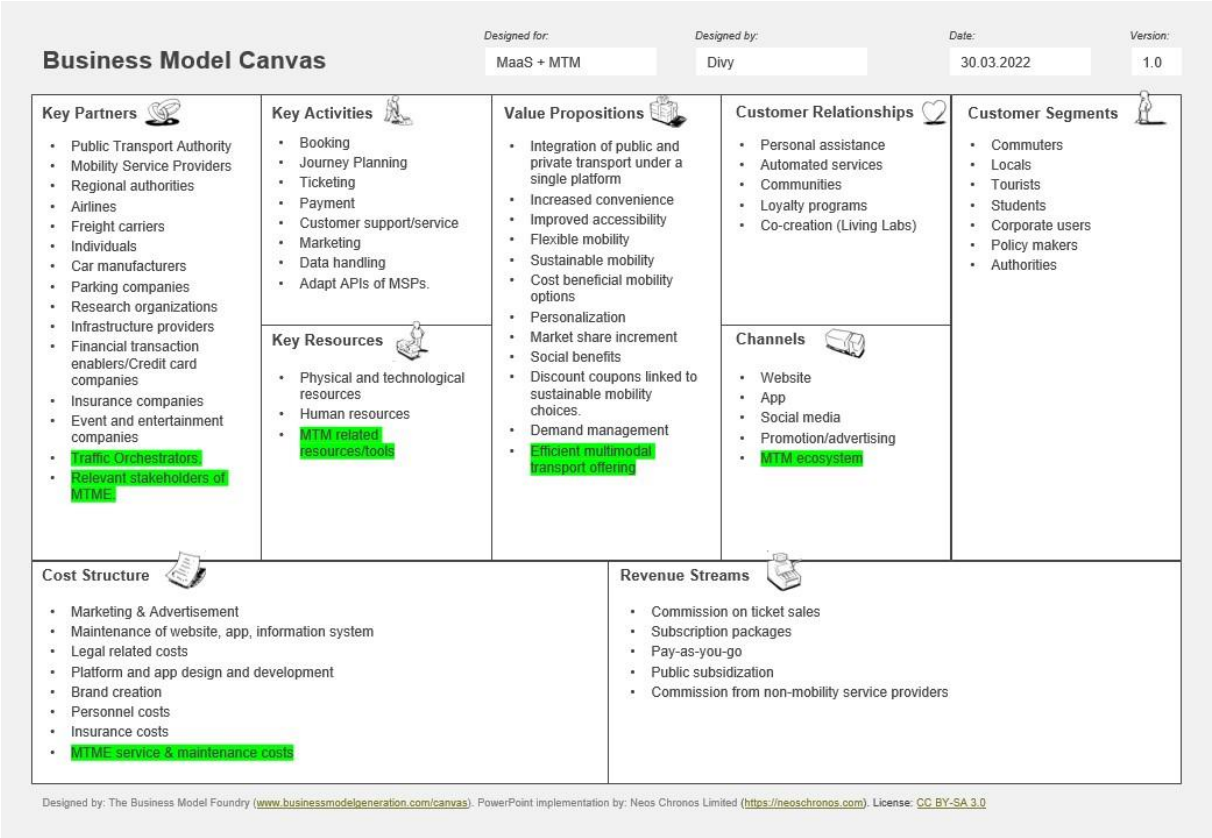

Figure 7 BMC of MaaS using MTM. Source: Own creation

Figure 8 describes the BMC of TO which is developed and verified by traffic management experts and project partners. There are several key insights and observations that should be drawn attention to, for instance, multiple key partners are often in the category of customer segments this indicates that TO should have close ties with its customers. There is a very high probability that in future TO might end up having a partnership with its own valuable customer. This makes perfect sense because TSP, FO, and NU collectively provide necessary resources which are required by TO, to carry out its day-to-day business. One of the key activities of TO is to offer cost efficient traffic management services. It also includes coordinating with other transport networks and modes, monitoring customers, handling and managing all the user data which is collected from the users and partners. Based on this raw data making decisions and predictions so that transport actors can complete their journey with minimum hassle and disruption. The possible revenue streams for a TO will be revenue generated from service offered. Apart from that TO might also need initial funding from government or transport authority. One can imagine a similar situation where public transport operator received certain funds from government to resume their operations post covid. This brings us to another critical aspect i.e., it is most likely that there may be influence of public authorities at administrative level in the TO operations reason being MTM is not widely accepted by private companies. As

per literature review evidence there's not enough private companies involved in this field. Hence a TO might need initial capital investment to offer their services. It is also critical to understand that traffic management in general is a service dominated business. In other words, authorities need to provide traffic management services to its citizens irrespective whether it is generating profit.

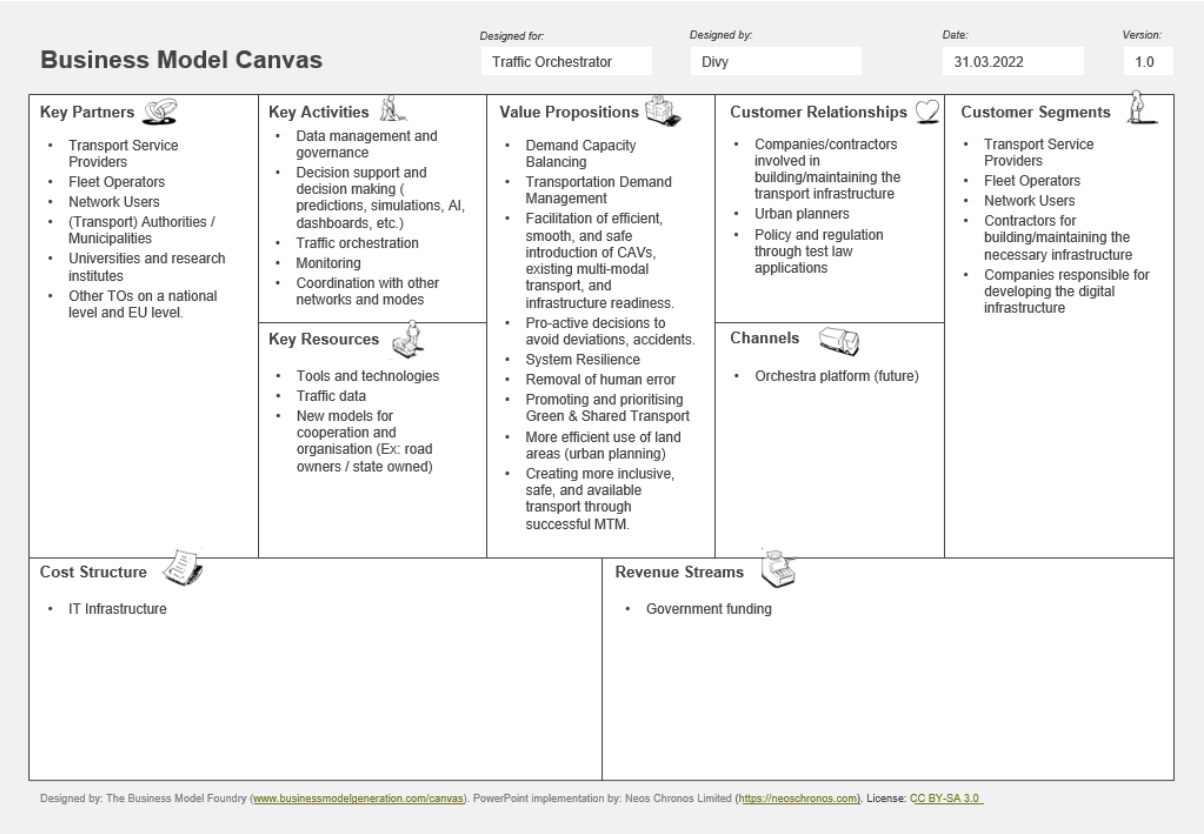

Figure 8 BMC of Traffic Orchestrator. Source: Own creation

Figure 9 is to be considered as a value-added information. This image gives a visual representation of how a BMC for an overall MTME platform would like. For instance, the biggest cost structure would include setting up of IT infrastructure required to carry out digital traffic management practices. Furthermore, once the setup is developed reasonable amount of cost is incurred for its maintenance. Moreover, the resources of similar platform might include real time traffic data, tools, and latest technology. It is imperative that an AI system requires huge amount of raw data to predict precise and accurate traffic information. Multimodal architecture of such digital platforms must be optimized regularly so that it can huge loads of data across different modes of transport. Some of the key partners involved in this arrangement could be TSPs, FOs, NUs, transport authorities, universities, research institutions, TOs on national and EU level. Customer segments comprises of contractors for building/maintaining

infrastructures, IT companies, infrastructure managers, public transport operators, private transport operators.

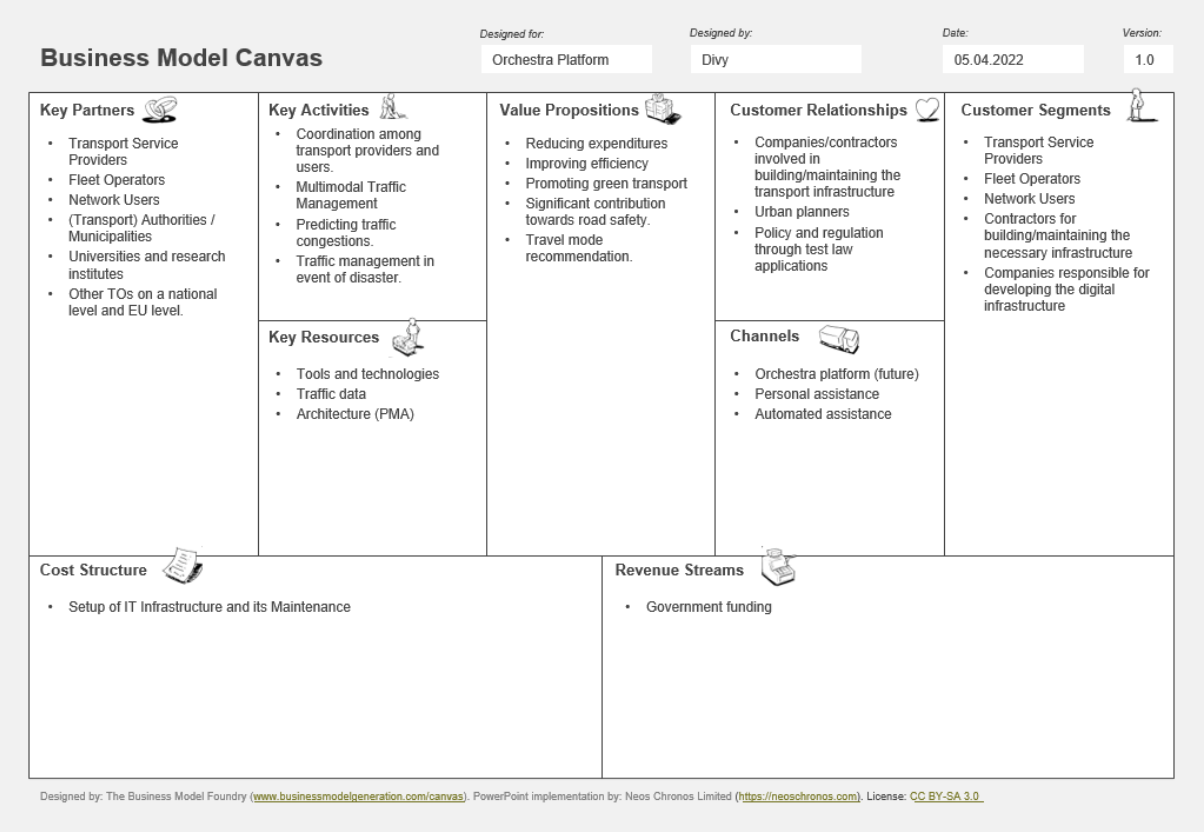

Figure 9 BMC of MTM platform. Source: Own creation

With the help of BMC one can easily identify economical advantages taking place within MTME. However, it is also important understand what kind of advantages MTM ecosystem can offer to the society and environment in general. To support this idea here value network method is utilized. One can also consider Value Network Method as a second level verification step for BMC. The Value Networks are developed as they were described in the background section and methodology section. The final versions of VNs can be found as below:

The value networks are developed based on four main stakeholder categories. Below one can find different combinations of value network diagrams. The idea is to identify different interactions taking place among the stakeholders simultaneously. Once that's done, we can have a closer look at the interactions and predict how MTM could be beneficial to each stakeholder and is not just limited to TO. It is important to keep in mind that value networks not only show economic interactions but also interactions which are beneficial from environmental and societal perspectives. For instance, the interactions between two stakeholders which are indicated by green line are the interactions from an environmental perspective. Similarly,

interactions indicated by yellow are the interactions which are beneficial to the society. Some interactions might be categorised as both economic and social in that case we've decided to consider such interactions under the category of social since their impact is large on the society in general.

One can find below the VN (Value Network) diagram between TO and FO. Here TO is the one who offers traffic management services to FO. Some key interactions happening from economical perspective are cost efficient traffic orchestration, opening the possibility of multimodal communication for FO. TO can offer extensions to AI dashboards and existing platforms used by FO so that they can have a seamless traffic related information. TO focuses on providing accurate and precise traffic information and hence it removes the possibility of human error which is relevant in today's traffic management scenario. Furthermore, TO offers data management and governance service to handle the user data. This will be done through with the help of blockchain technology. All the information will be decentralized and safeguarded, and only relevant stakeholders will have access to it. TO also offers services which are beneficial from an environmental perspective such as TO promotes and prioritize the use of green transport. This can act as a motivation for FO to include greener fleet and prioritize using it. The services offered by TO can also have positive impact on society such as it can improve safety, minimise disruptions and accidents. TO can guide FO in having an optimal fleet management which eventually will result in reducing the collective CO_2 emissions of FOs. The services offered by TO have reliance on the real time traffic information received from all the transport actors within the ecosystem. Even FO is responsible to provide real time data at regular intervals so that TO can take it into account and offer accurate and precise traffic information. TO can promote and prioritise green transport and it can influence FO to have offer sustainable fleet services to its customers. With the help of TO, FO can also integrate CAVs into their daily operations. Since CAVs are interconnected and can transmit real time traffic information. It can prove to be useful for every stakeholder. The objective here is not explain all the interactions happening among the stakeholders but rather to highlight important value interactions so that it can give readers a brief overview of direct and indirect benefits of MTME. Following the methodology and initial interactions readers should be able to interpret other interactions. Important thing to note is that one should keep an holistic view when it comes to analysing VNs.

Figure 10 Value Network Diagram of Traffic Orchestrator and Fleet Operator. Source: Own creation

Figure 11 indicates VN diagram between TO and NU. CAVs could play a critical role when it comes to seamless traffic management. TOs can provide precise accurate information to the NUs if the CAVs are more into circulation. Furthermore, with help of navigation systems and apps TO can monitor and guide NUs. If there's an increase in traffic flow in a particular direction perhaps TO can divert the traffic in alternate direction. NUs are also one of those carrying out transport operation. It is important to motivate them to use green transport. TO can do so by taking positive steps in this direction. There is a possibility where TO can offer discounts/cashbacks on using green transport, however it is difficult to comment how exactly this will be done. TO can further motivate NU to adopt multimodal transport. To have an efficient journey multimodal transport could be useful by having personalized preferences using digital tools and technologies. TO ensures that NU can get an optimal and safe transport journey with minimum delay and no disruption. To offer such services NUs need to share real-time data, live location via GPS, reporting via ETA, ETD throughout their journey. This will serve as a raw data for TO and based on it, TO can make forecasts and recommendations. TO can also communicate directly to the NUs in case of accidents, disruptions, or abnormal situation. Under this circumstance TO can directly guide NU and offer secured transport option since TO has a general overview of transport ecosystem.

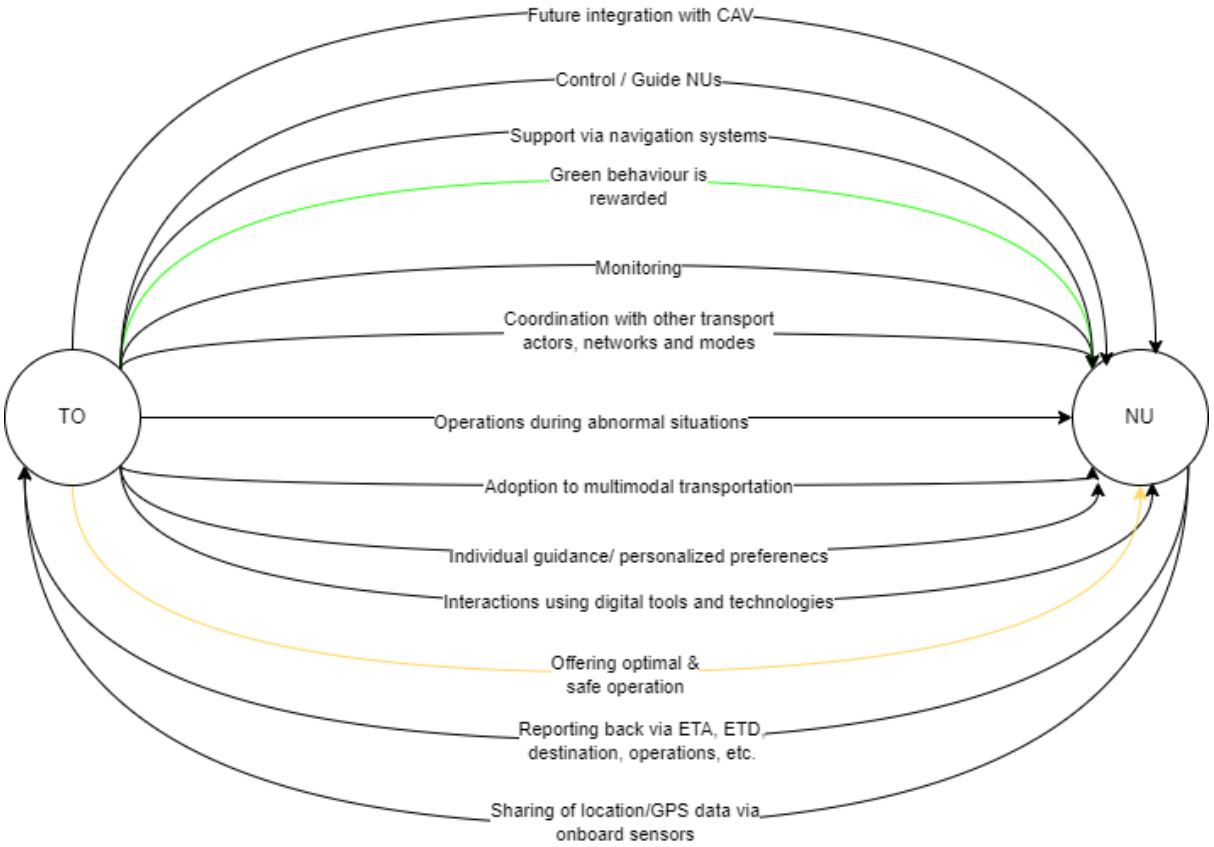

Figure 11 Value Network Diagram of Traffic Orchestrator and Network User. Source: Own creation

Figure 12 shows the VN diagram between TO and TSP. With the help of services offered by TO, TSP can improve their efficiency, ridership, reduce CO_2 emissions, reduce traffic congestion, efficiently handle disruptions, and involve CAVs in their transport operations. One can observe that the key interactions happening from environmental perspective are promoting green transport and reducing CO2 emissions. Also, from social perspective the important interactions are reducing traffic congestions, disruptions, efficient handling during disruptions, data transparency and security. Feedback on services provided is a critical aspect as well, this is to ensure that customers of TO are satisfied and taken care of. There are multiple ways to receive feedback for instance, survey, user feedback on website and apps and so on.

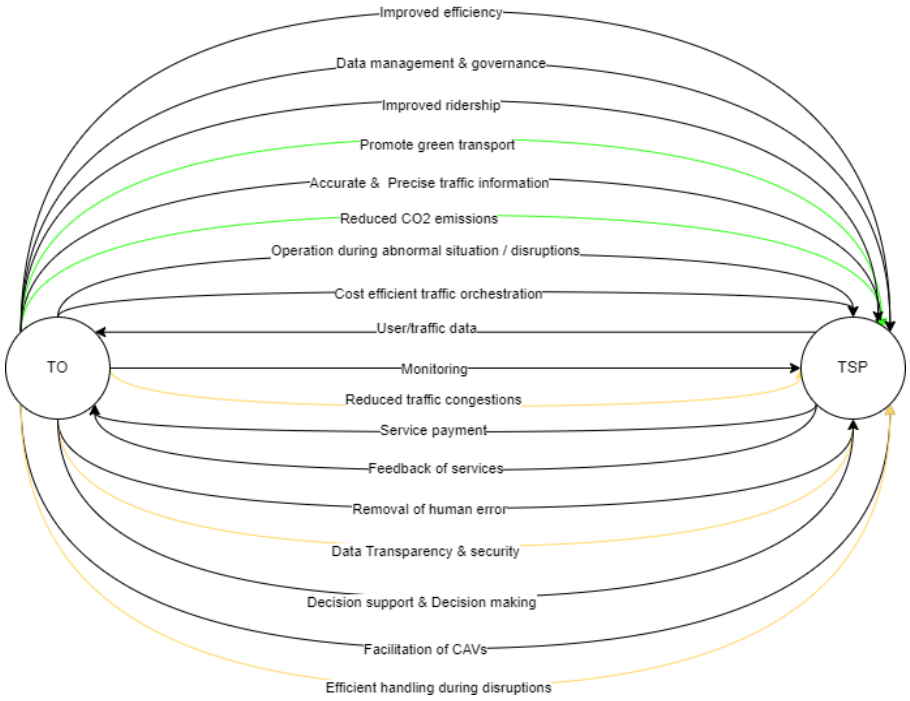

Figure 12 Value Network Diagram of Traffic Orchestrator and Transport Service Provider. Source: Own creation

Figure 13 shows the VN diagram of TSP and FO. TSP is the one offering transport services and FO is the one providing vehicle fleet to TSP and executes transport operations. With the help of a platform like MTME, FO can offer secure and reliable transport options to TSP also they can make optimal route planning for their customers. The diagram indicates various other interactions taking place among the stakeholders and explaining each of them is not critical. Reader can corelate to these interactions since they are used in general practice.

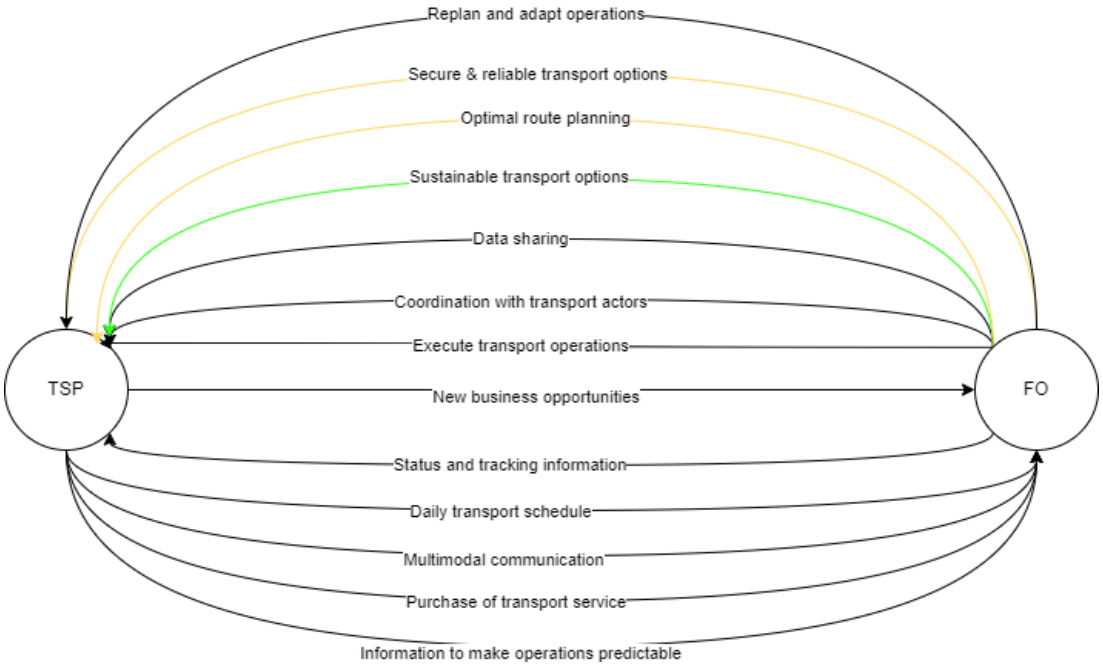

Figure 13 Value Network Diagram of Transport Service Provider and Fleet Operator. Source: Own creation

Figure 14 shows the VN diagram between TSP and NU. A NU could be pedestrian, Micromobility user, private vehicle owner, operator of a vehicle/vessel.(Marit K. Natvig et al. 2022) For a NU it is critical to have a safe transport journey. Hence the priority for an individual user is safety over other parameters. However, it is necessary to understand that NU can leave a fair share of carbon footprint and needs to be motivated to include green transport options in their journey. They can be motivated through giving reductions and discounts on using mode of transport. Also, the data received from NUs is important since they can showcase the live traffic forecast and based on the data received from them, one can plan and distribute the traffic accordingly. NUs are guided, navigated, and offered support via navigation systems. With the help of TO, TSP can offer journey planning support to their users in an efficient manner.

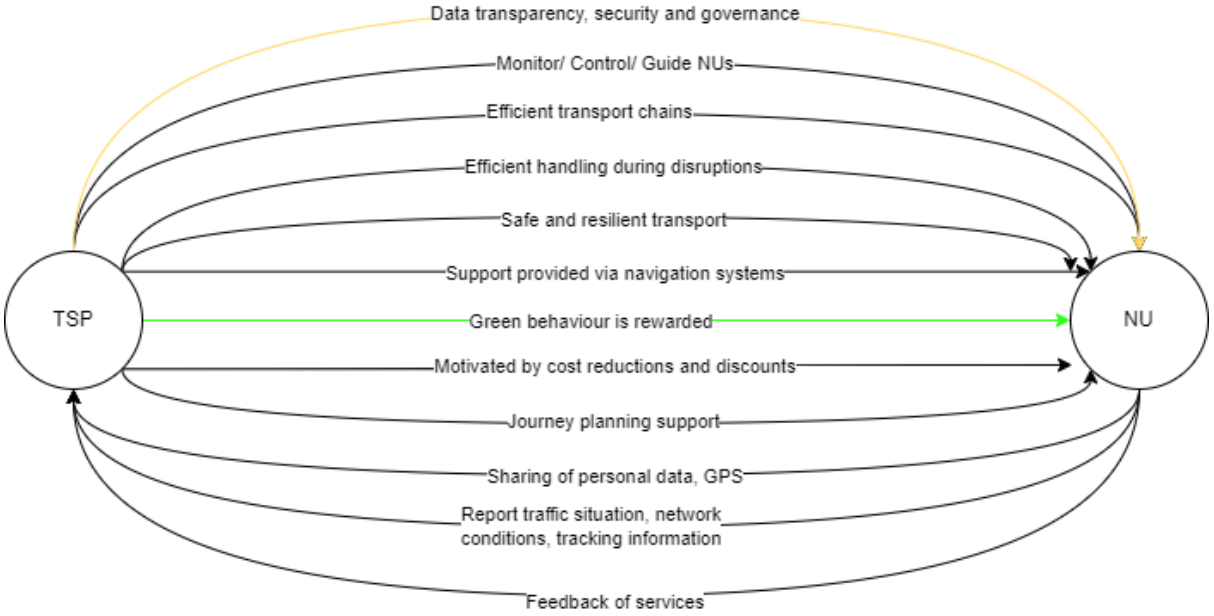

Figure 14 Value Network Diagram of Transport Service Provider and Network User. Source: Own creation

Figure 15 involves VN diagram between FO and NU. The highlighting interaction in this diagram is the accessibility to CAVs. FO can offer services of autonomous vehicles to its customers and as a result it could be a interesting bundle of service when a FO can offer their customer CAV service with a additional functionality of offering optimal transport plan/traffic management.

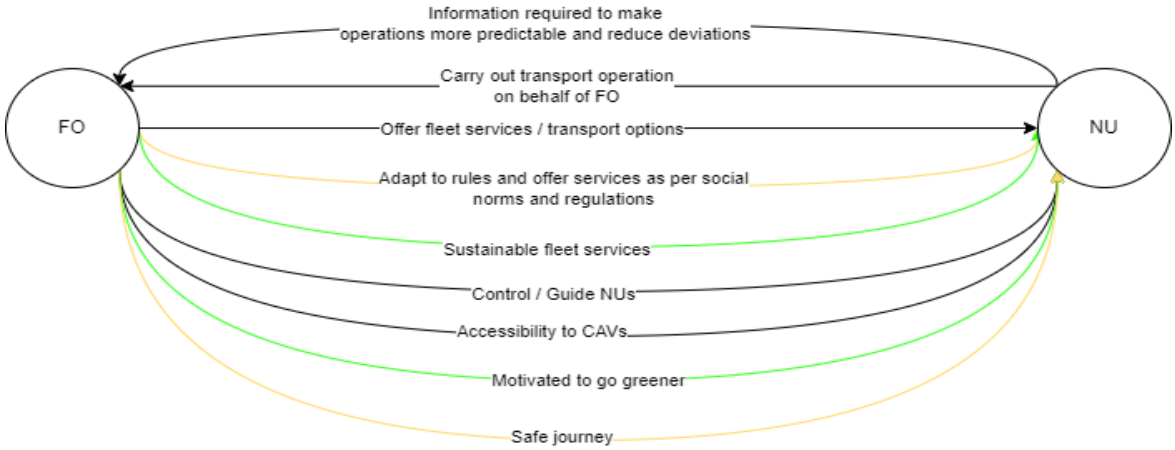

Figure 15 Value Network Diagram of Fleet Operator and Network User. Source: Own creation

So far we have explored two stakeholder based VN diagrams, this is done to understand different kinds of interactions taaking place between a pair of stakeholders. Moving to the next step, readers can see the three stakeholder based VN diagrams. This is done to understand interactions happening simultaneously among the three stakeholders. It is important to note that these diagrams are developed combining both present and future scenarios. The idea is to identify where and how an MTM can be beneficial to each stakeholder of the ecosystem in the future scenario. The key aspect to keep in mind is that many of the interactions taking place among stakeholders are the result of services offered by TO. For instance, TO offers an opportunity of opening the gateway of multimodal communication to FO, with its FO can coordinate in a better way with other transport actors. This could be bundled and offered as a new service by FO to TSP, where FO can utilize the multimodal communication to coordinate with other transport actors and complete the transport journey for TSP.

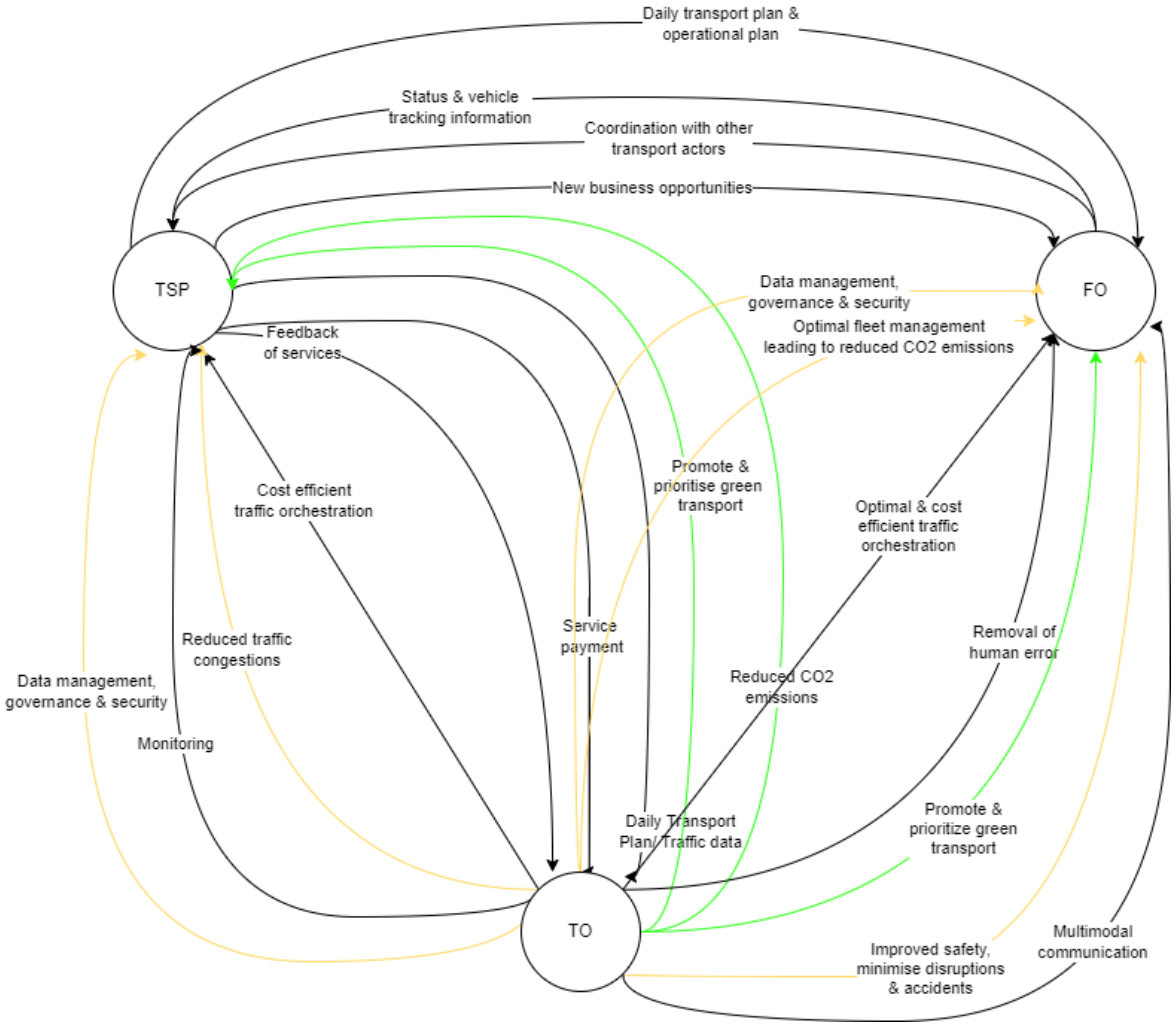

Figure 16 Value Network Diagram of Transport Service Provider, Traffic Orchestrator and Fleet Operator. Source: Own creation

Figure 17 shows the VN diagram between TO, NU and TSP. A reader can observe the trickle-down effect of one interaction among several stakeholders. For instance, TO influences TSP to promote and prioritise green transport. In return TSP can motivate NUs to use green transportation in their daily lives. This can be achieved via offering discounts and rewards. Hence this creates a complete chain of interaction where every stakeholder involved in benefited directly or indirectly. This understanding cannot be achieved via BMC and hence it is important to have a business model which has the holistic view of entire ecosystem and takes into account each and every stakeholder.

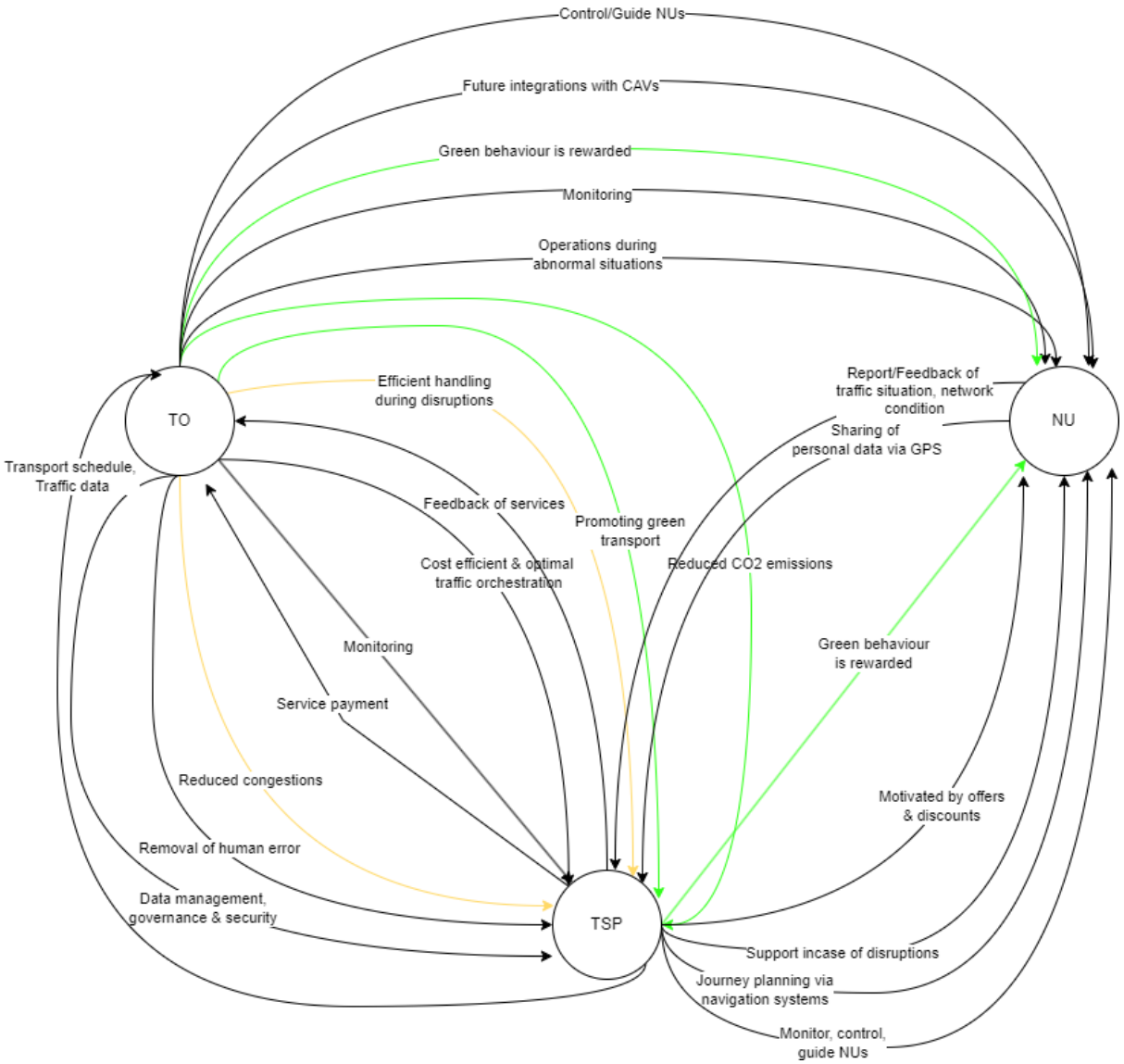

Figure 17 Value Network Diagram of Traffic Orchestrator, Transport Service Provider and Network User. Source: Own creation

Figure 18 displays the final four stakeholder diagram. It represents all the interactions happening within the MTME ecosystem. It covers the main stakeholders and lists out value exchanges happening within them. Needless to say this version of VN diagram is complicated and should be presented in a effieicnt manner. Based on visual representation it is evident that a 2-3 stakeholders are more than enough in a single VN diagram. A 4-stakeholder diagram is likely to cause confusion for a first time reader. Apart from that when given a closer look at interactions many of them may sound repetitive and redundant on a bigger scale, and such interactions should be addressed in an efficient way. Many interactions could be identified as economic as well social. It is important to take note of such interactions and these interactions should be dealt in such a way that end result is beneficial to the society in general.

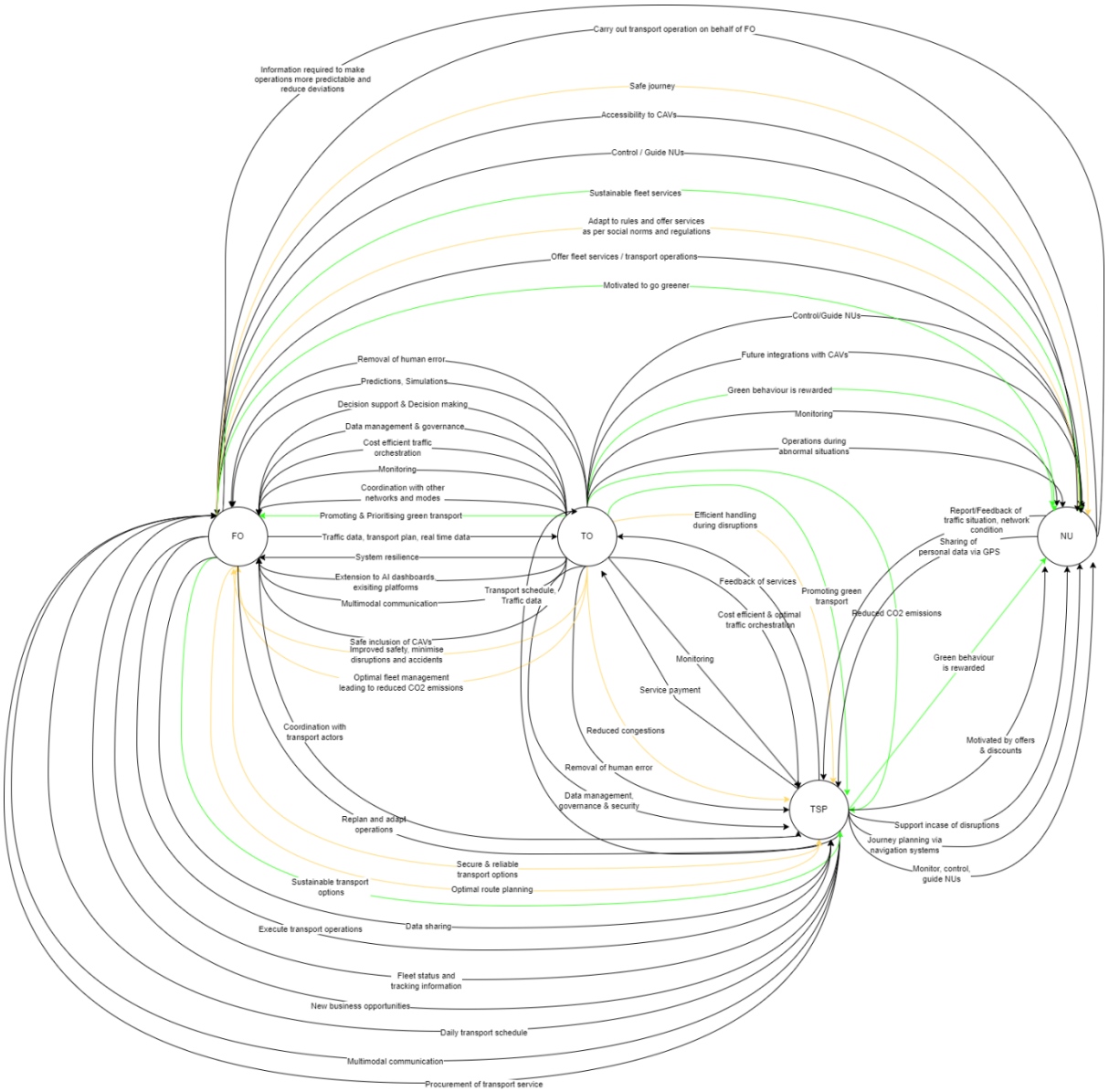

Figure 18 Value Network Diagram of Fleet Operator, Traffic Orchestrator, Network User and Transport Service Provider. Source: Own creation

It is necessary to create a simplified version of these value network diagrams and to do so I've created a list of parameters for identifying key/important interactions happening among the stakeholders/within the ecosystem. These parameters are developed based on the project requirements, inputs received from traffic management experts and project partners. The objective is to identify those interactions which are creating maximum value for the receipent stakeholders. The parameters for identifying external interactions are as follows:

- Interaction must be advantageous or should add value to the recipient stakeholder.
- Value should be enabled by Multomodal Traffic Orchestration/MTM.
- Interactions must be directly influenced by/related to the technical tools offered within the scope of research project.
- Knowledge flow which covers strategic alliance on planning/processing information is an interaction on the value network (informational value).
- Intangible benefits that are not covered by financial measures are interactions listed on the value network (e.g. benefits to the society/community).

Based on these parameters a new set of value network diagrams are created which showcases the most optimal value network information in a simplified way.

Figure 19 shows the optmised VN diagram between TO, TSP, and FO. The interactions flowing through these stakeholders could be considered as value propositions being offered to each and every stakeholder present in the ecosystem. The value propositions offered by TO to TSP are as follows:

- Economical:
    - Cost efficient & optimal traffic orchestration.
    - Reference architecture linked to AI dashboards and existing mobility platforms.
    - Flexibility to integrate multimodality.
    - Reduction of human error through automated processes.
    - Guidance during abnormal situations, disruptions, accidents.
    - Future integration & accessibility to CAVs.
    - Flexibility of chossing contractors.
- Social:
    - Optimal utilisation of whole transport network across all modes.

- Ecological:
    - Promoting & prioritising green transport.

Value propositions offered by TO to FO are as follows:

- Social:
    - Reduced road congestions due to leass private vehicles.
    - Improved safety, minimise disruptions and accidents.
    - Data governance & security.
- Ecological:
    - Sustainable fleet services.

Value propositions taking place between TSP and FO which are influenced by MTM are as follows:

- Economical:
    - Innovative business opportunities.
    - Integration & Inclusion of MaaS applications.
    - Coordination with other transport actors, networks and modes.
- Ecological:
    - Promoting & prioritize green transport.

For the sake of simplicity, I've eliminated repetative interactions so that readers can identify unique interactions.

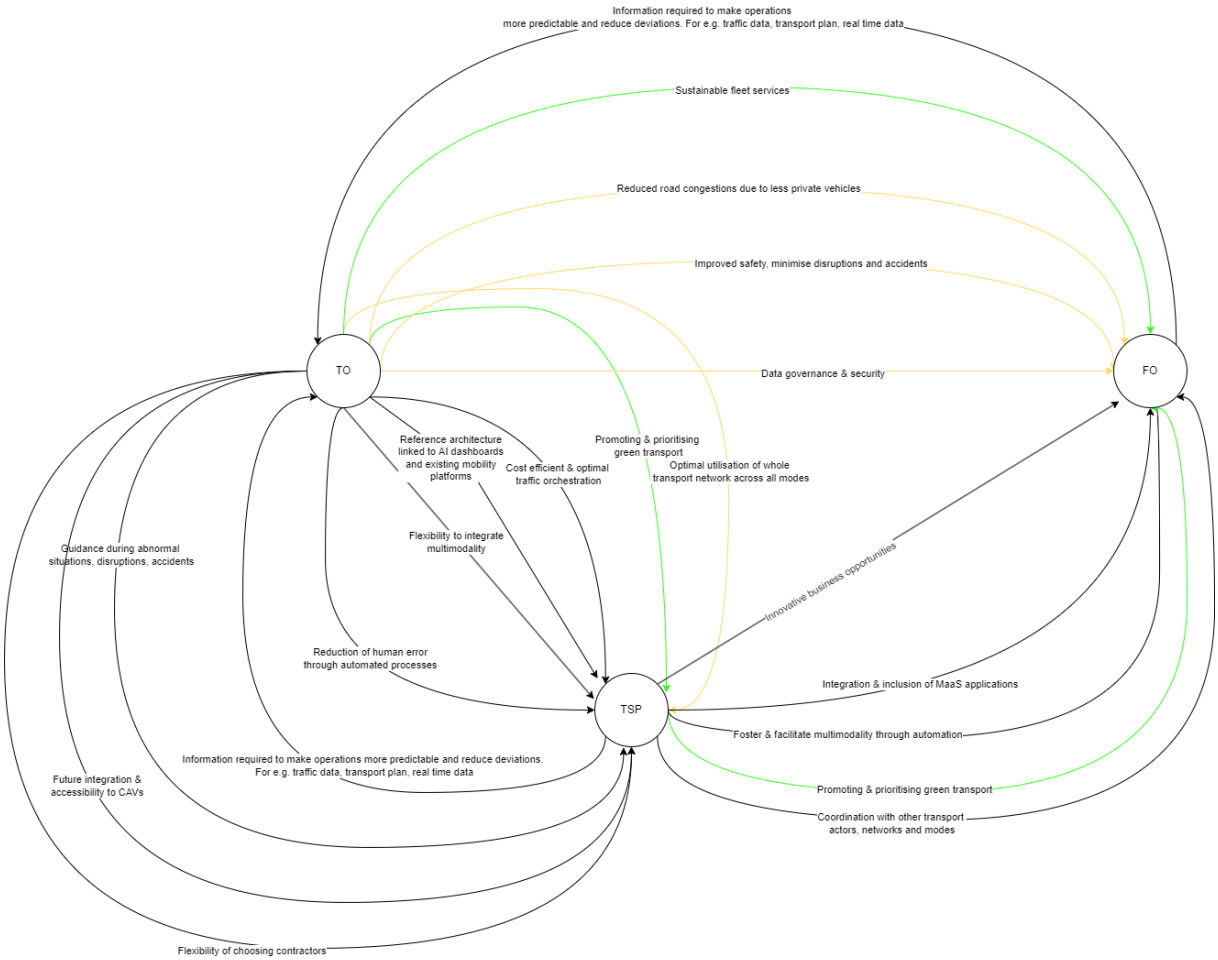

Figure 19 Optimized VN diagram between TO, TSP and FO. Source: Own creation.

Similarly figure 20 shows the optimised VN diagram among TSP, FO, and NU. Since value propositions between TSP and FO are already discussed in the earlier VN diagram, there's no need to repeat the same information again. On the contrary reader can have a look at value propositions offered by TSP to NU are as follows:

- Ecological:
    - Sustainable transport options.
    - Encouraging multimodal travel behaviours.

Value propostions offered by FO to NU are as follows:

- Economical:
    - Reduced overall waiting time and down time.
    - Future integration & accessibility of CAVs.
- Social:
    - Optimal route planning.
    - Reduced road congestions due to less private vehicles.
    - Vehicles running at optimal capacity.
- Ecological:
    - Reduction in overall energy/fuel consumption.

Interaction such as “reduction in overall energy/fuel consumption” can be categorized as ecological as well as economical value proposition.

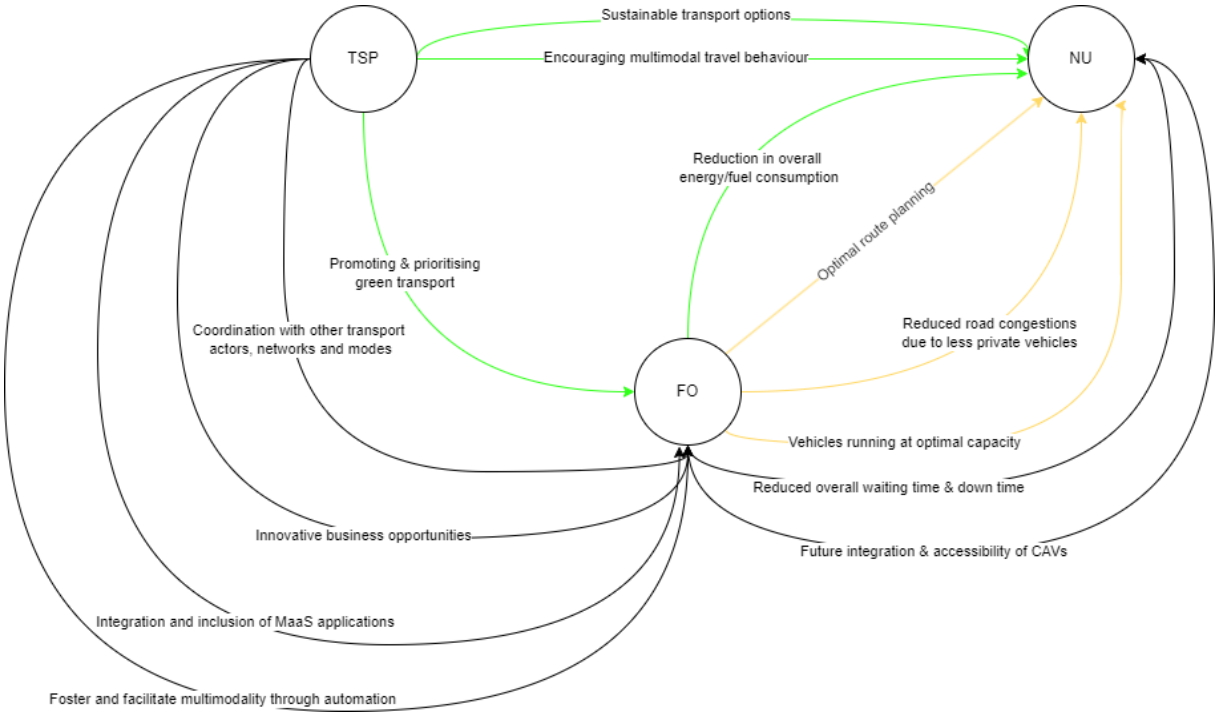

Figure 20 Optimized VN diagram between TSP, FO, and NU. Source: Own creation.

Figure 21 indicates the optimized VN diagram between TO, TSP and NU. Value propositions offered by TO to NU are as follows:

- Economical:
    - Guidance during abnormal situations, disruptions, accidents.
- Social:
    - Efficient use of public infrastructure.
    - Vehicles operating at optimal capacity.
- Ecological:
    - Reduction in overall energy/fuel consumption.

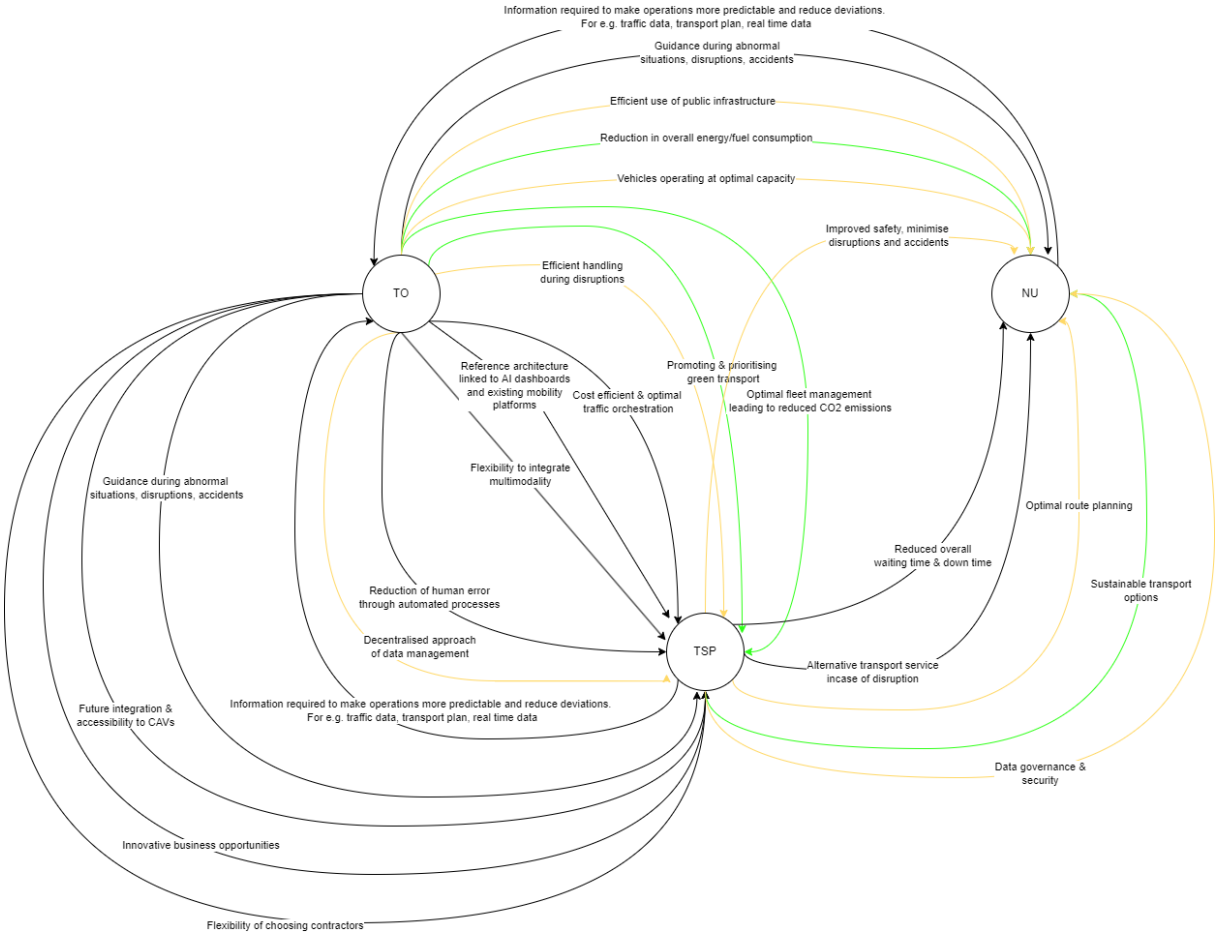

Figure 21 Optimized VN diagram between TO, TSP, and NU. Source: Own creation.

Figure 22 is the visual representation of 4-stakeholder diagram. Ideally this diagram consists of multiple interactions and when all these interactions are plotted in a single diagram the result becomes difficult to understand. This shows that there is a dire need of further simplification of value network diagrams. The result must be simplified as much as possible. Below mentioned figure gives a generalized overview of how a 4-stakeholder diagram might be. The 4-stakeholder diagram must be optimised in such a way that all the stakeholders can be associated with economic, social, and ecological benefits. It should give an birds eye view of the entire MTME.

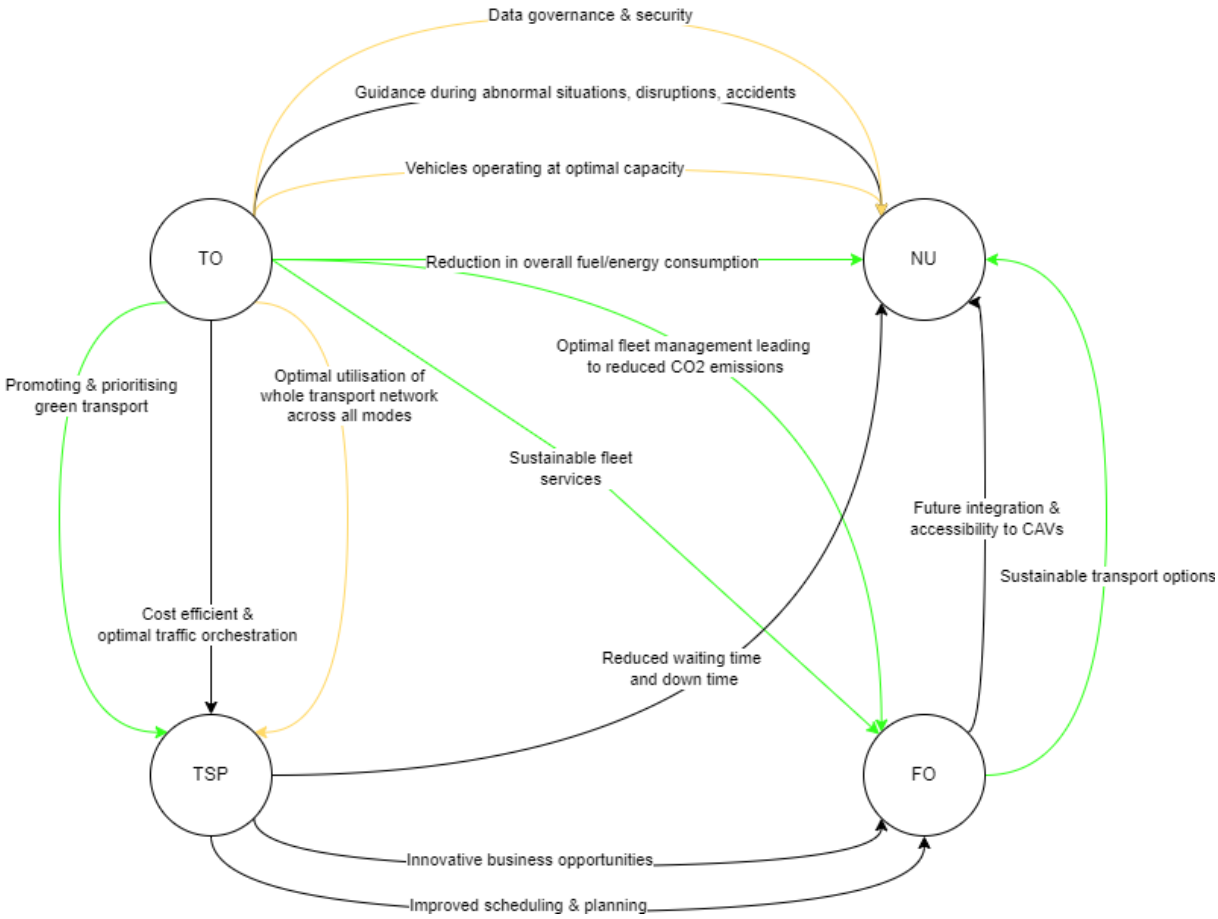

Figure 22 Optimized VN diagram between TO, TSP, NU, and FO. Source: Own creation.

Once the value network diagrams are constructed, next steps include associating the results with triple bottom line approach. To showcase the sustainability of MTME I've listed out all the interactions happening in the ecosystem into a tabular structure, which highlights the value propositions happening within the ecosystem.

Economic	Ecologic	Social
Improved scheduling & planning	Avoiding unnecessary expansion of transport infrastructure	Data governance and security
Reduced overall waiting time and downtime	Optimal fleet management leading to reduced CO2 emissions	Efficient handling during disruptions
Cost efficient & optimal traffic orchestration	Optimal utilisation of whole transport network across all modes	Efficient use of public infrastructure
Information required to make operations more predictable and reduce deviations. For e.g. traffic data, transport plan, real time data	Promoting and prioritising green transport	Improved safety, minimise disruptions and accidents
Guidance during abnormal situations, disruptions, accidents	Encouraging multimodal travel behavior	Decentralised approach of data management
Data management & governance	Facilitating multimodal journey planning	Optimal route planning
Reduction of human error through automated processes	Sustainable transport options	Reduced road congestions due to less private vehicles
Future integration and accessibility of CAVs	Sustainable fleet services	Optimal utilisation of whole transport network across all modes
Decision support & decision making during disruptions	Efficient use of public infrastructure	Secure and reliable transport operations
Monitoring	Reduction in overall energy/fuel consumption	Regulation and standardisation of digital infrastructure
Coordination with other transport actors, networks and modes		Framework for future traffic management solutions
Transport network resilience		Vehicles running at optimal capacity
Reference architecture linked to AI dashboards and existing mobility platforms		
Multimodal communication		
Avoiding unnecessary expansion & spending of transport infrastructure		
Feedback/evaluation of services provided		
Service payment		
Report/Feedback of traffic situation, network condition		
Balancing demand across transport networks through offers and discounts		
Reduction in overall energy/fuel consumption		
Journey planning via navigation systems		
Replan and adapt operations		
Innovative business opportunities		
Flexibility of choosing contractors		
Opportunities for strategic alliances		
Integration and inclusion of MaaS applications		
Collaboration with other stakeholders		
Foster and facilitate multimodality through automation		

Figure 23 Value propositions according to triple bottom line approach. Source: Own representation.

This table resembles triple bottom line approach which was mentioned in the methodology section. There are 3 different columns each indicating economic, social, and ecological categories. The rows resemble to the value propositions which are offered within the scope of MTME for all the relevant stakeholders. These values resemble inclusivity of MTME. It shows that benefit of each stakeholder is taken into consideration.

9. Conclusion

MTM is an innovative concept and needs equal amount of technological readiness as well as organizational readiness. Technological infrastructure needs to be developed across EU to have a seamless flow of traffic information across all modes of transport. Furthermore, regional as well as international governance need to address cooperative and collaborative nature internally to exploit maximum potential of MTM.

We can have a sustainable business model for a MTME in near future. However, to achieve a particular level of sustainability there are certain terms and conditions associated with it. For instance, data sharing: all the stakeholders involved in the ecosystem must be motivated to share data with relevant stakeholders. It is necessary to check which data needs to be shared, find right level of abstraction which data to be shared. We can solve transparency issues because not all data needs to be shared with every stakeholder. Companies need to be aware what they really need to share and not share all data with the free world. Decentralised approach of data management can act as a motivating factor for private companies.

Traffic Orchestrator is the entity responsible for carrying out traffic orchestration across all modes of transport. There will be influence of public as well as private entities when it comes to the organizational decision making. A certain capital investment is required at initial level to get TO running and operating, which can only be done through with the support of public authorities. Efficient and robust technical infrastructure can be developed by private organizations across EU. Hence a PPP model is the optimal solution in this case.

Traffic management is a service dominant business domain. This means that public authorities are under obligation to offer traffic management services to their citizens keeping aside profit-making mindset. Based on the literature review it is evident that there are very few private companies operating in MTM. This could be interpreted as private companies do not find MTM an lucrative domain. However, MTME can offer lucrative business opportunities, such as it opens the gateway to have a more collaborative environment within the ecosystem where companies see each other as partners and not as competitors. MTME allows the flexibility of choosing contractors, this reduces the dependency on one supplier and service providers can achieve desired results on time. Overall MTME is more inclined towards improving transport ecosystem and betterment of the society in general. And hence it is in my opinion that a sustainable business model within MTME could be possible only if ecological and social benefits are considered as central pillars.

10. Future Remarks

By this point it is evident that a combination of maximum 3 stakeholder VN diagram is sufficient and easy to understand. A 4-stakeholder diagram consisting of all the interactions happening simultaneously would result in the similar state of confusion where it becomes difficult to interpret. This is an indicator that a further level of simplification is required which should make it easier for readers to interpret the correct information. Further, there could be multiple small stakeholders within MTME, it is not just limited to four main stakeholder types. These small stakeholders can act as a bridge to make the vale exchanges possible.

Furthermore, this study is developed within the framework of research project, so the continuous evaluation of business model canvases and value network methodology will take place. The next steps for improving results will be a workshop which will be attended by industry experts and project partners and VN diagrams will be discussed and evaluated. With the help of experts, it is expected to achieve a more accurate for of VN diagrams. The results achieved from the workshop will again be verified with traffic management experts in the form of semi qualitative interviews. This should help in achieving progressive results.

The final version of business models is developed, based on scenarios, use cases, target visions, pre-studies, expert interviews, and workshops. Furthermore, to develop flexible and resilient business models the findings are implemented in Living Labs. Living Labs acts as open innovative platforms and are made up of different stakeholders such as firms, public agencies, universities, institutes. The Living Lab associated with passenger transport is the Milan Malpensa Airport in Italy and Heroya Industrial Park in Norway. The objective of Living Labs is to implement these business models in their daily operations and give feedback from an administrative perspective and suggestions for improvement. At the later stage, Living Labs will play a critical role to support in testing of software tools, simulations, and user trainings.

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12. Appendix

In this section readers can find information which could be useful for business modelling practices. There are multiple methods for business modelling. In this study I've focused on Business Model Canvas. However, I had taken into consideration two other business modelling methods which are:

- Reinventing Your Business Model by Mark W. Johnson, Clayton M. Christensen, and Henning Kagermann.
- The Entrepreneur's Business Model: Toward a Unified Perspective: Michael H. Morris, Minet Schindehutte, Jeffrey Allen

Eventually I proceeded with Business Model Canvas since it is well established tool within the mobility field and easy to understand, even for a novice reader. However readers can have a detailed look at the other two methodologies as per their interest.

Reinventing Your Business Model by Mark W. Johnson, Clayton M. Christensen, and Henning Kagermann.

Managers find it difficult, to identify what is wrong with their business model or when are they supposed to make alterations in their business models. The reason behind this is there are limited studies done which indicates changes required in the business model. To overcome this hurdle authors, suggest answering following questions:

1. What makes your model successful? What customer problem does it solve? How is your company making money from it?
2. Look out for signals which indicates change in your model such as entry of new competitors.
3. Is reinventing worth the effort the answer is yes only if the new model changes the entire market or industry.

Authors suggest that a successful business model should have the following components:

- Customer Value Proposition (CVP): The model should help customers performing a specific job which no other competitors in the market are able to offer. One way to generate a precise CVP is to identify barriers which customers face to get their job done for e.g., insufficient wealth, skill, time.

- Profit formula: The model should generate profit to the company based on the factors like, revenue model, cost structure, margins, and Resource velocity. Cost structures are usually dominated by the cost required of key resources in the business model. Margin model gives an idea, how much contribution is needed by each transaction to make profits. Resource velocity indicates how fast do we need to refill inventory to support our volume of selling which will help in achieving anticipated profits. The best strategy is to determine the price of CVP and then work backwards on the cost structures and margins. This gives an idea on volume of resource velocity needed to achieve desired profits.
- Key resources: A company should have right technology, human capital, infrastructure, and brand to deliver value to the targeted customers. The focus here is on the key elements that create value for the company as well as for the customers.
- Key processes: Key processes include recurrent tasks such as training, development, manufacturing, sales, service, budgeting. Successful firms have processes which allow them to deliver values, repeat them and increase their scale.

These four elements form the building block of any business. Each element is interdependent on one another. Model should be devised in such a way that each element complements to one another. One way of creating a competitive advantage is to merge key resources and processes and then offer it to the customer, this can be used as a USP by the companies. The following image gives a simplified version of four components:

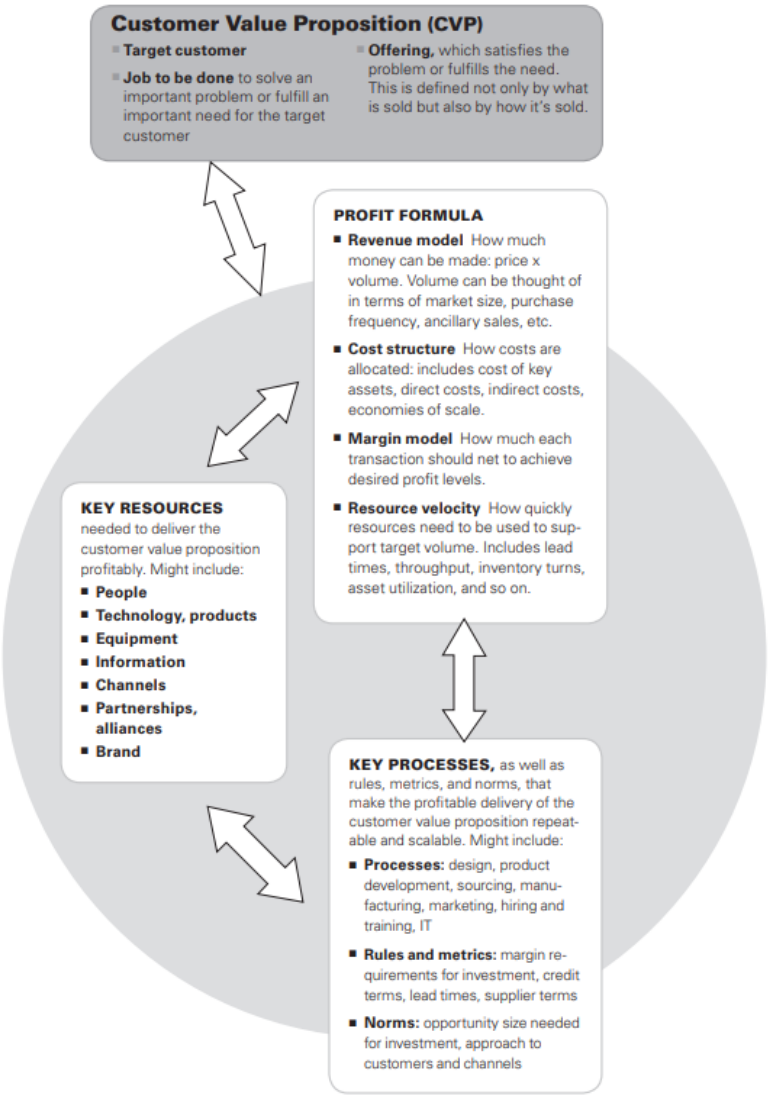

Figure 24 Elements of a Successful Business Model. Source: Johnson et. al.

The Entrepreneur's Business Model: Toward a Unified Perspective: Michael H. Morris, Minet Schindehutte, Jeffrey Allen.

There is no general definition for business models, also business models have received limited attention from the researchers. Even though business models are critical for a new business venture. The author synthesizes several literatures and proposes a general definition for business model for all venture types. This article provides theoretical support to develop and explore business models for firms. A six-component framework is proposed for characterizing business models across all industries. Since there is no general definition of business models it often terminologies like business model, strategy, concept, revenue model is used interchangeably which creates confusion in terminologies. To resolve this issue, author makes a content analysis of 30 different definitions provided by authors and identify them in three general categories of definition. These categories are defined as economic, operational, and strategic; each is comprised of set of decision variables.

The first category is firm's economic model and the objective here is profit generation. Decision variables in this category include revenue sources, pricing methodologies, cost structures, margins and expected volumes. Second category is operational, and it signifies architectural configuration. The emphasis here is laid on internal processes and design of infrastructure that generates value to the firm. Decision variables in this category include production or service delivery methods, administrative processes, resource flows, knowledge management, and logistical streams. The third category is called strategic, and it focuses on firm's market positioning, growth opportunities, competitive advantage, and sustainability. Decision variables include stakeholder identification, value creation, differentiation, vision, values, and networks and alliances.

Based on this categories and decision variables and referencing to well-known business models (e.g., Dell, WalMart, IKEA) author proposes a general definition for business models:

Furthermore, author proposes that well formulated business model must address six key questions. These questions are developed based on theoretical underpinning of business models. The first question addresses value offered by the firm. Here the emphasis is laid on how the offering is made available to the customer. The objective here is to define value proposition. The second question focuses on the nature and scope of market in which the firm competes. Customer types, their demography, are dealt in this question. The third question focuses on the core competency of the firm. Developing competencies helps firm in increasing their external

value. This leads the way to fourth question which focuses on positioning in the marketplace. This question helps in identifying key competitive advantages over competitors. Through this firm can define their unique offerings. The fifth question talks about firm's economic model. Which focuses on pricing and revenue sources, whether the cost structure is dominated by fixed cost or variable cost. The sixth question deals with firm's investment model. This helps a firm in understanding what kind of investment model they prefer in the long run.

With these proposed frameworks of six components evaluating them in three levels, can help a standard foundation level for all the business models irrespective of their framework. The business model can serve as a guiding tool to entrepreneurs and employees in times of making critical decisions.

Initially I also created BMCs for passenger transport companies, freight & logistics companies, MaaS aggregators. To develop these canvases, I have taken into consideration business models of companies such as Deutsche Bahn, DB Regio, DB Schenker, Uber, S-Bahn Berlin, BVG, Lufthansa Cargo, A.P. Moller Maersk, Finnish public transport model, Last mile delivery companies. Readers can have a look at the original version of BMCs which does not include any information regarding MTM.

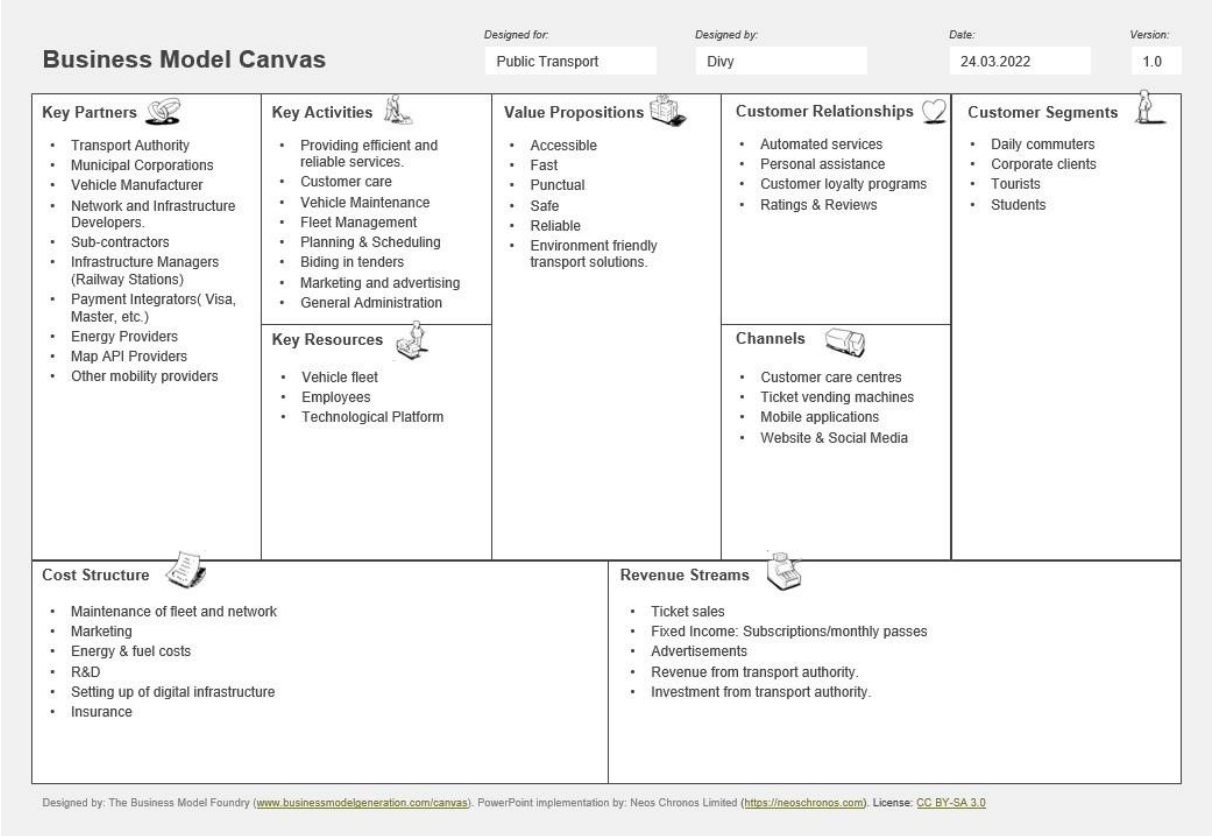

Figure 25 BMC of public transport. Source: (Steve Wright 2015), (Innovation Tactics 2022), (Florian Kressler, Gabriele Grea, and Anja Seyfert 2019), (Deutsche Bahn AG 2021a), (S-Bahn Berlin 2022), (Berliner Verkehrsbetriebe (BVG) 2019)

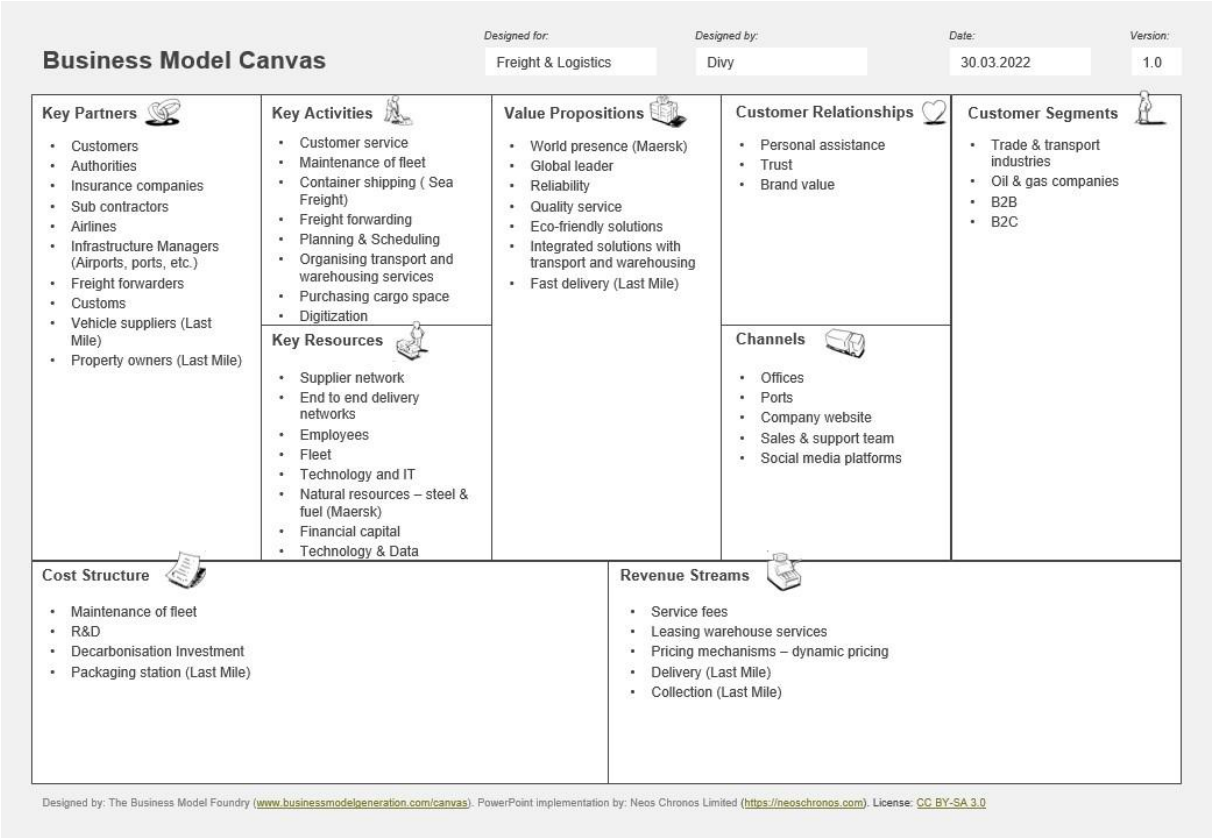

Figure 26 BMC of freight & logistics companies. Source: (Finn Glismand, Henrik Jensen, and Sarah Spray 2022), (Lufthansa Group 2022), (Kien Do Trung et al. 2020).

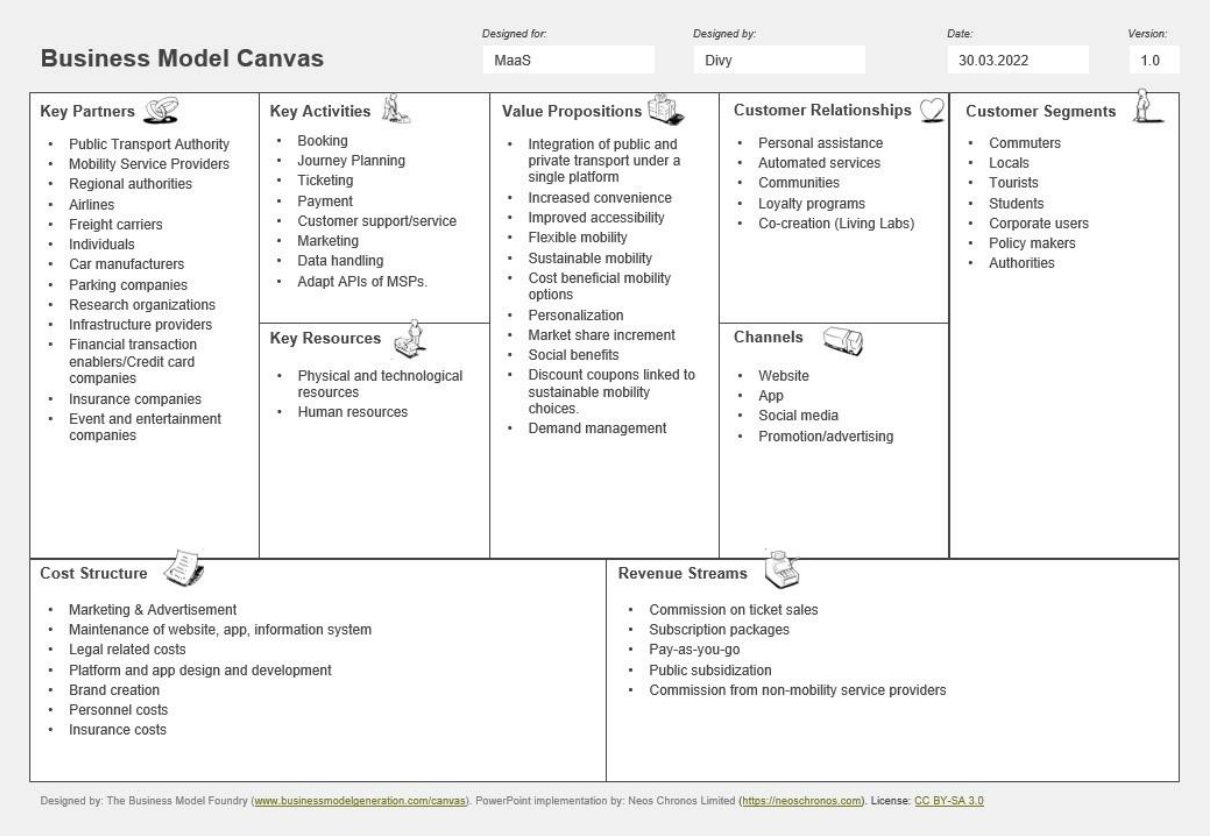

Figure 27 BMC of MaaS company. Source: (David König et al. 2016)