CHALMERS
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Emerging Business Models in Integrated Terrestrial and Non-Terrestrial Networks

A Study of Connectivity Provisioning in Rural and Remote Areas and Autonomous Flying Taxi Services

Master's thesis in Management and Economics of Innovation

DAVID BOMAN
GABRIEL GERAGHTY

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF ENTREPRENEURSHIP AND STRATEGY

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Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

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Abstract

The telecommunications industry is undergoing a significant shift with the integration of terrestrial and non-terrestrial networks, leading to widespread connectivity that supports a variety of new applications. However, there is considerable uncertainty about how the business landscape will evolve for these new applications. This thesis sheds light on the emerging business landscape by investigating two specific use cases: connectivity for rural and remote areas, and autonomous flying taxis. It does so by constructing value networks for each use case, identifying a central actor, and analysing them using the business model canvas framework. Additionally, it explores potential financial interactions among the network's participants. The research is grounded in qualitative data collected from 12 interviews and two focus groups with experts, predominantly from the telecom vendor Ericsson, and is further supported by documentary and academic sources. The study reveals that a new role, dubbed the 6G NTN Operator, is required for the provision of connectivity solutions for rural and remote areas, acting as a bridge between mobile network operators and satellite network operators. In the case of autonomous flying taxis, another new role is identified, dubbed the AAM Connectivity Operator. This actor makes use of a combination of terrestrial and non-terrestrial network infrastructure to provide a full connectivity solution for flying taxi operators and other advanced air mobility actors. The findings underscore the necessity of collaborative efforts among all parties in the value networks for the successful delivery of emerging connectivity services, providing valuable insights for actors in the telecommunications industry.

Keywords: telecommunication, terrestrial networks, non-terrestrial networks, 6G, flying taxi, remote connectivity, business models, value networks, business model canvas, revenue models

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David Boman and Gabriel Geraghty, Gothenburg, June 2024

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis.

3GPP	3rd Generation Partnership Project
AAM	Advanced Air Mobility
CISP	Common Information Service Provider
eVTOL	Electric Vertical Take-Off and Landing
GEO	Geostationary Orbit
HAPS	High-Altitude Platform Station / High-Altitude Pseudo-Satellite
IODT	Interoperability Development Testing
IoT	Internet of Things
LEO	Low Earth Orbit
LTE	Long-Term Evolution (4G)
KPI	Key Performance Indicator
MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator
NTN	Non-Terrestrial Network
OSS/BSS	Operations/Business Support System
RAN	Radio Access Network
SLA	Service-Level Agreement
SNO	Satellite Network Operator
TN	Terrestrial Network
UAM	Urban Air Mobility
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aircraft System
USSP	U-Space Service Provider
UTM	UAS Traffic Management
VRIS	Valuable, Rare, Imperfectly Imitable, and Non-Substitutable
QoS	Quality of Service

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Introduction

In the following chapter, a background to the topic is presented, followed by the study's research questions, purpose, and delimitations.

1.1 Background

Wireless connectivity has transformed the way we live in innumerable ways, enabling communication across massive distances in just an instant. Almost every facet of society has been permeated by wireless communication, yet new technologies and ways of utilising them are still constantly being conceived of and introduced to the market. This study will explore one of the areas in which our perception of connectivity is set to be altered yet again.

1.1.1 Evolution of Wireless Communication: From 5G to 6G

The transmission of mobile data has been improved dramatically over the past few decades, with the current emerging standard for telecommunication being 5G. This latest evolution has allowed for speeds up to 100 times higher than those of 4G networks, as well as a number of new use cases, including such things as network slicing and a wide variety of Internet of Things (IoT) applications (Ericsson, 2021).

6G is the name of the sixth generation of mobile networks, which is expected to become commercially available sometime in the early 2030s (Ericsson, n.d.-b). This new standard has been envisioned to support considerably higher rates of data than was previously possible, while also being more reliable and able to support a number of new, innovative applications. Among other things, this increased performance will allow it to play an integral part in enabling the proliferation of networks in the sky.

1.1.2 Non-terrestrial Networks and Aerial Platforms

Non-terrestrial networks (NTN) are networks whose communication platforms are air- or spaceborne (Giordani & Zorzi, 2021). These can include satellites, stratospheric vehicles known as High-Altitude Platform Stations (HAPS), and Unmanned Aerial Vehicles (UAV), also known as drones. The telecommunication towers of conventional, ground-based networks, known as terrestrial networks (TN), are typically not able to reach devices at high altitudes, in part due to them usually having directional antennas that are pointed down towards the ground (Bae et al., 2022). While pointing these antennas upwards can go some way to provide coverage in the sky, it is the integration of TNs with NTNs that will achieve this on a larger scale.

As Figure 1.1 shows, the envisioned scenario is an omnipresent, 3D network that provides coverage for devices at all altitudes (Mozaffari et al., 2021; Wikström et al., 2020). This enhanced connectivity, facilitated by advancements in space and aviation industries, is set to enable a myriad of new use cases and business opportunities.

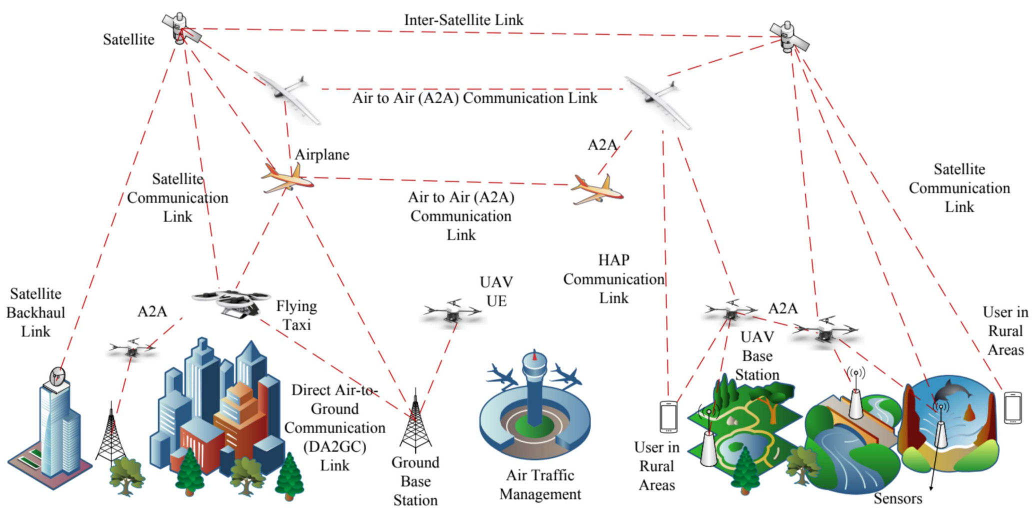

Figure 1.1: Vision for integrated terrestrial and non-terrestrial networks (Ozger et al., 2023)

1.1.3 Use Cases for Integrated TN and NTN

The idea of using satellites and airborne vehicles for telecommunication is certainly not new. When it comes to consumer technology, satellite phones have been available since the 1990s (Lim et al., 2005), and more recently, limited satellite connectivity has been added to the latest iPhone models with the addition of special hardware (Apple, 2023). Past attempts at providing network access on a wide scale include Alphabet's Project Loon, a venture in which helium balloons were used as base stations (Matracia et al., 2024). This ultimately failed, giving way to current projects such as Starlink by SpaceX, in which thousands of satellites have been deployed in order to provide broadband access to its users via antenna receivers in areas beyond the reach of TNs (Y. Li et al., 2023).

The integration of TNs and NTNs is set to drastically increase this business area, both in terms of users and in the sheer amount of applications. This is especially true in a future 6G landscape, as indicated by Ozger et al. (2023), who present a number of potential use cases, such as increased connectivity in commercial airplanes, urban air mobility (UAM), connectivity for rural and remote areas, IoT, and more. It is clear that applications for this technology will be varied and far reaching, undoubtedly introducing many new business opportunities.

Connectivity for rural and remote areas emerges as a particularly interesting use case here. Only 15% of the planet is covered by cellular networks (Iridium, 2022). Apart from the inconvenience of not being able to communicate freely, this lack of coverage can hinder people from making emergency calls when in need of help in remote areas, and serves to reinforce the digital divide and hold economic development back in rural villages (Cabrera-Castellanos et al., 2021). Due to their lower subscriber density, installing terrestrial cellular infrastructure in many of these areas is not financially viable (Feltrin et al., 2021), but it is believed that employing NTNs here could be (Charbit et al., 2021), thus massively increasing the area in which reliable voice, messaging and data features are accessible. This would improve public safety and widen the potential number of customers of cellular services (Jeux et al., 2019).

UAM is another use case showing much potential, although this study will predominantly use the broader term advanced air mobility (AAM), as that also includes rural areas. AAM refers to a range of different examples of uses of UAVs, including medical emergency missions, surveillance, and logistics (Straubinger et al., 2020), and a particularly interesting one is that of autonomous flying taxis. This use case has been envisioned as a service that allows customers to board large UAVs and fly to a desired destination, much like taxis of today. This will require the existence of designated landing pads, known as vertiports. Flying taxis are expected to travel within a city, as an airport shuttle, or transport commuters between nearby cities (Hader et al., 2020).

There has been development in both of these areas. For example, the aforementioned Starlink has partnered with several mobile operators, including T-Mobile in the US, and launched satellites that are meant to connect directly to unmodified phones to enable the operators' subscribers to send and receive texts in remote areas (Sheetz, 2024). Drones to be used as autonomous flying taxis are being developed by a multitude of different companies (Lyth, 2023), indicating a potentially lucrative industry.

Management consulting firm Roland Berger echoes this sentiment, estimating that the UAM market will reach an annual revenue of $90 billion, with 160,000 commercial passenger drones in the sky by 2050 (Hader et al., 2020). Morgan Stanley estimates that the AAM market will be worth $2.3 trillion at least, and $19 trillion at most by 2050 (Adam et al., 2021). While the quantification of the industry's value clearly varies somewhat, it is obvious that this use case shows a lot of potential. This creates a clear incentive for actors in this space to make significant investments into new technology in order to gain early market share.

The potential of these new wireless networks is evident. However, likely due to the fact that the markets for them are either new or as yet non-existent, previous studies have only touched on some aspects of the commercialisation of the technology. Yrjölä et al. (2023) provide insight into the likely stakeholders of a broader 6G ecosystem, including infrastructure vendors, mobile operators, device manufacturers, and satellite manufacturers. Dinc et al. (2017) investigate the case of in-flight broadband connectivity for 5G. An area that still lacks clarity is that of the structure of the business models and the involved actors of the emerging use cases enabled by the integration of TN and NTN within 6G. This study aims to shed light on this matter.

Beyond academic contributions, this study will have significant implications for industry stakeholders. Identifying and anticipating emerging markets and trends informs strategy and guides the direction of R&D for companies (Battistella, 2014). By providing insights into the emerging business models, this study aims to empower industry players with new knowledge to navigate and capitalise on new business opportunities enabled by the new technology.

1.2 Research Questions

The provisioning of connectivity to rural and remote areas and unmanned flying taxis are two emerging use cases requiring new mobile data services. These two use cases in particular were chosen to be studied as they in combination provide a good overview of the potential of TN-NTN integration. Connectivity in rural and remote areas was seen as a subtle yet powerful feature that could be integrated into modern day mobile phones, making it easy for most people to imagine how it would work. Conversely, AAM was seen as a more revolutionary use case, affecting a large number of industries and changing how we view the transport of goods and people. To facilitate understanding and productive discussions, the decision was made to centre research around a specific example of AAM, that being autonomous flying taxis.

The provisioning of mobile services is often viewed in terms of value networks, consisting of different actors co-creating value that is then delivered to the end customer (Peppard & Rylander, 2006). Identifying the necessary actors and their roles for the different use cases is important in order to understand where value lies and how the activities of different actors affect the network (Peppard & Rylander, 2006). The specific configurations of these value networks play an important role in the success of the participating firms (Al-Debei et al., 2013; Peppard & Rylander, 2006). It is therefore important for players looking to participate in the provisioning of these services to understand the potential value networks to best position themselves.

Yrjölä et al. (2023) have gone some way to identify key stakeholders in an envisioned future 6G business ecosystem. However, this research gives a broad overview which, while valuable, fails to provide any specific constellations of actors involved in the value networks and the roles they play in individual use cases, such as those identified by Ozger et al. (2023). Therefore, the first research question this study will be guided by is:

RQ1: In an integrated TN and NTN 6G scenario, what are the key actors and roles within the emerging value networks in i) connectivity for remote and rural areas and ii) connectivity for autonomous flying taxi services?

A business model as defined by Osterwalder and Pigneur (2010) is the rationale of how a company creates, delivers, and captures value. In the context of value networks, Peppard and Rylander (2006) define the network focal as the actor in the value network whose business model relies on the value network. Understanding the business model of the focal actor can provide insight into the value proposition for the network as a whole, which can be beneficial for actors at different parts of the network to understand their role in the value creation. Therefore, the second research question is:

RQ2: For each case in RQ1, what elements will constitute the business model of the network focal?

In their study on the emerging business for in-flight broadband connectivity, Dinc et al. (2017) explore possible models for money flows between the network of actors required for delivering the connectivity. The transfer of money is the other side of the exchange that takes place when one actor provides value to another. This is thus an important aspect to describe, to allow potential future actors to understand in what way their work may be compensated, and to give a comprehensive view of the business model. The third research questions that will guide this study is:

RQ3: What are the potential money flows between the actors identified in RQ1?

1.3 Purpose

This thesis aims to conceptualise emerging business models in the integration of terrestrial and non-terrestrial networks within the context of 6G.

1.4 Delimitations

The scope of this report will be limited to two of the aforementioned use cases for 6G TN-NTN integration, these being (1) connectivity for rural and remote areas, and (2) autonomous flying taxi. This is largely due to time constraints, as well as a preference for a few in-depth, credible analyses over a larger amount of surface-level analyses.

Due to the interconnected nature of the economy, models of value networks (more thoroughly explained in the theoretical framework section of this report) run the risk of becoming overly complex, and thus obscuring the relevant information, if every single connection is mapped out. To avoid this, only components of the value networks that enable, facilitate, or are directly affected by connectivity will be considered.

2

Theoretical Framework

This chapter consists of two parts. First is an extended background that contextualises the environment and describes the technologies in which the use cases under analysis will operate. The subsequent section presents the theories that underpin the analysis, providing the concepts upon which the study will be grounded.

2.1 Extended Background

In the following section, some of the technologies discussed in this report are explained in more depth.

2.1.1 Telecommunications Industry

Key aspects of the telecommunications industry, including network components, telecom actors, and network concepts, will be explained below.

2.1.1.1 Network Components

The *Core Network* is one of the two main components of a telecommunication network (Handa, 2009). The core network handles connection and mobility management (Ericsson, n.d.-a), meaning that it is here that calls get rerouted and users get connected to the greater network. Today's networks have a variety of features, including authentication and authorisation, subscriber data management and more (Ericsson, n.d.-a). Furthermore, support systems such as operations and business support systems (OSS/BSS) are necessary for functions such as charging and billing (Handa, 2009).

The *Radio Access Network* (RAN) is the second main component of the telecommunication network, and refers to the infrastructure, both physical and digital, enabling the transmission of wireless signals between user equipment and the core network (Dahlman et al., 2021; Handa, 2009). Its functions include the management of radio resources, controlling what devices are allowed onto the network, and establishing connections (Dahlman et al., 2021). The main components of a RAN are the antenna, the remote radio unit and the baseband unit (Larsen et al., 2024). The antenna sends and receives remote signals, the baseband unit communicates with the core network, and the remote radio unit transmits, receives and converts signals between the antenna and the baseband unit (Lam et al., 2022).

2.1.1.2 Telecommunications Actors

Mobile Network Operators (MNO) are wireless carriers who own and operate the infrastructure required to maintain a mobile network (Shavers & Bair, 2016). They also own their own spectrum rights (Vuojala et al., 2020), meaning that only they have the right to transmit cellular signals within a certain range of frequencies in their geographical area. There are typically only a small number of MNOs in any given country (Vuojala et al., 2020).

Mobile Virtual Network Operators (MVNO) are wireless carriers who do not own their own network infrastructure, instead providing a service that makes use of the RAN from MNOs and selling their own packages to customers (Balon & Liau, 2012; Shavers & Bair, 2016). There are different categories of MVNOs. Typically, MVNOs will differentiate themselves through offering lower prices, targeting certain ethnic groups or geographic areas (such as areas near borders), or going after corporate customers (Balon & Liau, 2012).

Vallina-Rodriguez et al. (2015) describe two main kinds of MVNOs. *Light MVNOs* do not own any network infrastructure at all, only employing their own branding and marketing. *Full MVNOs* on the other hand, own their much of their own network infrastructure, such as a core network, only making use of the MNO's RAN, and are thus able to create more differentiated offerings.

For the case of in-flight entertainment, Dinc et al. (2017) describe an actor known as an Air-to-Ground Operator, that acts as an MVNO for the passengers of the airplane that aggregates the networks of various MNOs and SNOs, using the best connection depending on current geographical location. In the paper, one scenario presented is that this operator could simply be a business entity acting as a middle layer between the passengers and the network of operators. However, it is also suggested that the presence of a core network could facilitate smooth handovers between various operators.

2.1.1.3 Network concepts

Roaming is when the subscriber of a particular network is able to connect to another operator's network (Salsas & Koboldt, 2004). Typically, the provider of the visited network charges the user's home operator a wholesale fee for the network capacity that has been used, and then the home operator charges the user a roaming fee, also based on the capacity used (Spruytte et al., 2017). This requires a roaming agreement between the home operator and the visited network operator, although there are also companies that act as roaming brokers, creating a network of roaming partners and thus sparing individual operators from having to make agreements with operators all over the world (Salsas & Koboldt, 2004). Due to the large amount of operators around the world and the logistical complexity of establishing roaming agreements with all of them, most operators only make a limited number of direct roaming agreements, and rely on roaming brokers in all other cases (Liaqat & Køien, 2023).

Network Slicing is a concept that involves partitioning networks into several logical virtual networks (Zhang, 2019) while benefiting from them using one common network infrastructure (Yrjölä et al., 2021). This creates a number of dedicated virtual networks that can be customised and adapted to serve specific services or customers (Ericsson, 2021; Zhang, 2019). Applications include customised industrial automation and enterprise services (Yrjölä et al., 2021), and resources that are allocated to each network can be dynamically scheduled and redistributed to suit shifting demand (Zhang, 2019).

2.1.2 6G

While the design of 6G is likely to be based on that of 5G, it is set to surpass previous generations in multiple ways (Wikström et al., 2020), thus enabling a wide array of new use cases. Features that could be seen as obvious, natural progressions from 5G will likely include higher data rates (Lin et al., 2024; Mishra et al., 2021; Siriwardhana et al., 2021; Wang et al., 2023; Wikström et al., 2020), a larger number of connections (Mishra et al., 2021; Wang et al., 2023), ultra-low latency (Lin et al., 2024; Mishra et al., 2021; Wang et al., 2023; Zong et al., 2019), ultra-high positioning accuracy, lower energy requirements and higher security (Wang et al., 2023).

In addition, 6G is envisioned to be able to support such things as AI applications (Ericsson, n.d.-b), augmented/virtual reality (Ericsson, n.d.-b; Lin et al., 2024; Mishra et al., 2021), blockchain technology (Ericsson, n.d.-b), e-health (Ericsson, n.d.-b; Mishra et al., 2021), digital twins (Ericsson, n.d.-b), and most importantly for this report, global coverage facilitated by networks in the sky as well as underwater (Khanh et al., 2023). All this indicates that 6G is set to foster innovation in ways previously not possible.

2.1.3 Aerial Platforms

There are a number of different kinds of aerial platforms that will enable NTNs. These include different kinds of satellites, High Altitude Platform Stations (HAPS) and Unmanned Aerial Vehicles (UAV) (X. Li et al., 2024). Saarnisaari et al. (2020) suggest that NTNs may involve the coordination of multiple different kinds of aerial platforms, at different altitudes.

2.1.3.1 Satellites

GEO satellites orbit the Earth at an altitude of 35,786 km and a velocity of 3 km/s from west to east above the equator, allowing them to remain in a fixed position relative to Earth (European Space Agency, 2020), allowing for continuous connections to terrestrial terminals (Giordani & Zorzi, 2021). Because GEO satellites are so far away from Earth, they are able to cover extremely large areas, with three equally spaced out satellites being able to reach anywhere on the planet (European Space Agency, 2020).

LEO satellites orbit the Earth at altitudes 160-2,000 km (European Space Agency, 2020; Giordani & Zorzi, 2021; Riebeek, 2009). These satellites are not required to orbit along the equator, and so their flight paths can be chosen more freely. They also travel considerably faster than GEO satellites, at speeds of about 7.8 km/s. As this is too quick for any individual satellites to provide reliable coverage on their own, they may be deployed in constellations to compensate for this and provide continuous coverage (European Space Agency, 2020; Giordani & Zorzi, 2021).

2.1.3.2 HAPS

HAPS are aerial platforms that fly at altitudes of 20-50 km above ground within a specified area (Anicho et al., 2023). They can come in a number of different forms, including balloons, gliders, zeppelins and airplanes (Alexandre et al., 2021; Piesing, 2023). By making use of solar power, HAPS have the potential to be self-sustainable (Renga & Meo, 2022) and remain in the sky for months at a time (Alexandre et al., 2021; Baurreau et al., 2015).

Due to their operating altitude, HAPS employed as base stations could provide network access for considerably larger areas than conventional TNs while still remaining quasi-stationary (Alexandre et al., 2021; Renga & Meo, 2022). They are very fast to deploy, providing flexibility to the network while also potentially decreasing overall energy consumption (Renga & Meo, 2022). Unlike satellites, they make use of the same spectrum bands as TNs, so users can connect to them using conventional phones (Alexandre et al., 2021), although satellites could potentially be made compatible with this too (Anicho et al., 2023).

2.1.3.3 UAV

UAVs, also known as drones, are flying, unmanned vehicles that are either remotely controlled, fly along predetermined paths, or operate autonomously. They can be equipped with a multitude of sensors, including gyroscopes, accelerometers and cameras in order to regulate their flying and avoid collisions, or to collect and send data (Benos et al., 2023). The main categories are rotary wing (known as mono-copters, quad-copters etc.) and fixed wing UAVs, (Benos et al., 2023; Laghari et al., 2023), although flapping wing UAVs also exist (Benos et al., 2023).

UAVs have been envisioned as both enablers and users of NTNs. As with HAPS, they will be used as base stations in order to provide access in remote areas, during emergencies when TNs are down, or to offload the main network in times of high congestion, such as sports or music events (Chang et al., 2023; Kumar et al., 2018; Mishra et al., 2021). Additionally, there are numerous other potential uses for UAVs, including monitoring infrastructure and agriculture, photography and filming, law enforcement, package delivery, etc. (Benos et al., 2023; Laghari et al., 2023). While traditional base stations are expected to be able to provide network access for UAVs in some of these applications, provided that they have antennas aimed up at the sky, many of these use cases are dependent on the integration of TNs and NTNs (Mozaffari et al., 2021).

2.2 Theoretical Concepts

The following section presents the theoretical concepts which will be used to analyse the findings of this study.

2.2.1 Value Networks

This section will introduce concepts relating to the ways in which different firms interact with each other to create value.

2.2.1.1 Inter-firm Relationships

Relationships between firms come in different forms. Basole (2008) describes different kinds of inter-firm relationships, including partnerships, alliances, joint ventures, licensing agreements, and manufacturing collaborations. Transactions costs, resource dependency, and organisational learning are noted as the three main reasons for firms to engage in inter-firm relationships. In recent times, resource dependency has become more relevant as products and services have become more complex.

2.2.1.2 From Value Chains to Value Networks

The concept of value chains was established by Michael Porter, who defined it as a tool for analysing all activities performed by a firm, and how they interact (Porter, 1985). The author recognised that the output of one firm's value chain is in turn the input of a buyer's value chain. Together, these links of value chains make up what is known as a value system (Porter, 2001). It is beneficial for a firm to understand its own value chain as well as its own position in the greater value system in order to gain and sustain a competitive advantage. In this view, an organisation's strategy lies primarily in its positioning within the value system.

While the concept of value chains has been widely used and subsequently developed, several authors (Biem & Caswell, 2008; Peppard & Rylander, 2006; Ricciotti, 2020) note that there has been a shift from the concept of value chains to that of value networks. Peppard and Rylander (2006) attribute this to the fact that inter-firm relationships now play a more significant role in performance, a result of digitisation and increased cooperative behaviour in many industries. Ricciotti (2020) identifies six main mechanisms which have made the concept of value networks more suitable than that of value chains: sustainability, globalisation, collaboration, intangible assets, flexibility, and agility.

The concept of value networks captures inter-organisational exchanges in an attempt to provide a better model for today's complex and dynamic business environment (Biem & Caswell, 2008). Allee (2008) defines value networks as a set of roles and interactions where people exchange both tangible and intangible goods to achieve social or economic good. In contrast to the concept of value chains, where activities follow a linear sequence to transform inputs into products, activities within the value network are performed simultaneously, requiring continuous coordinated adjustments between different actors (Stabell & Fjeldstad, 1998). In today's landscape, competition is mainly waged between networks of interconnected organisations, rather than between individual firms (Peppard & Rylander, 2006). This makes the concept of value networks appropriate for analysing many modern industries, including the telecommunications industry.

2.2.1.3 Analysis of Value Networks

The concept of value networks as an analytical framework appears to have seen an increase in popularity as of late. Böhm et al. (2010) use value networks to analyse the cloud computing industry, while Riasanow et al. (2017) use it to map out the automotive industry in the advent of emerging digital innovations. This also extends to the telecommunications sector, with Al-Debei et al. (2013) using value networks to analyse mobile data services and Peppard and Rylander (2006) instead using the concept to analyse the provision of mobile services and develop strategic implications for mobile operators.

Much research has been done on the analysis of value networks (e.g. Allee, 2008; Biem and Caswell, 2008; Gordijn et al., 2000; Peppard and Rylander, 2006; Stabell and Fjeldstad, 1998). While there is no single ontology to describe value networks, they all include some representation of actors as nodes connected by links that represent a flow of goods, services, money, knowledge, or any other type of exchange. Gordijn et al. (2000) propose the e3-value model, in which actors are independent entities that can represent either a company, an organisation, or a customer. Actors deliver or receive value objects to and from other actors through value ports. Allee (2008) proposes a different value network model that includes roles, transactions, and deliverables. Roles are either individuals, small groups, business units, or entire organisations who contribute some value to the network. Allee (2008) further highlights that it is useful to analyse a value network in terms of roles and not confusing them with an entity that is trying to fill that role at a given time. Transactions entail some activity between actors, and are represented by arrows. Deliverables are the physical or non-physical things that move from one role to another.

The value network modelling framework proposed by Biem and Caswell (2008) will be used for this study. This model employs a simple terminology and allows for both descriptive and prescriptive strategic analysis. It involves the mapping of economic entities, which can be viewed as either an actor, a set of capabilities, or assets. The economic entities of a network collaborate to deliver value to the end customer. Economic entities are linked by their offerings, which can take five different forms: product, service, brand, information, and coordination. A product is simply defined as a transferable, for which ownership is passed on to the recipient. A service is an offering in which the state of something that is supplied by the recipient is transformed. A brand is a form of prior awareness among customers that indicates that the potential value generated by the economic entity is high. A coordination offering is something that is present in the network-based perspective and involves the management of network actors and their offerings. These offerings are visually distinguished through the use of arrows in different colours. This modelling framework is shown in Figure 2.1.

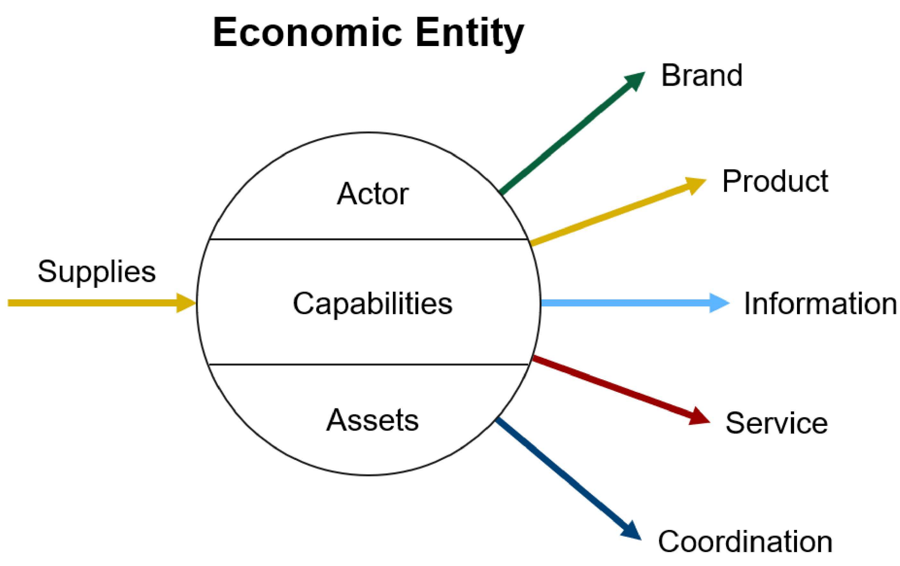

Figure 2.1: Modelling of an economic entity and different offerings (Biem & Caswell, 2008)

Peppard and Rylander (2006) describe a role known as the *network focal*, this being the actor in the value network whose business model depends on the network. It is suggested that the network focal should be the starting point for the analysis, and that it must be considered when defining the network's boundaries. Actors included in the value network should be those that influence or are influenced by the value that the network focal creates, which ultimately gets delivered to the end consumer. Biem and Caswell (2008) note that the end consumer is a special node in a value network, as they consume and appreciate the value proposition of the value network rather than contribute to it.

2.2.2 Strategic Management

Peppard and Rylander (2006) describe *opportunity networks* as emerging value networks that do not yet exist. It is argued that the way to analyse such networks is to determine the forces that are shaping them. To this end, analysing opportunity networks requires understanding fundamental strategic management concepts shaping the strategies of actors in the telecommunications industry.

2.2.2.1 Transaction Cost Economics

In transaction cost economics, transaction costs are seen as the basic unit of analysis for the organising of economic activity (Riordan & Williamson, 1985). These are the costs that occur as a result of purchasing in the open market, including the cost of searching, as well as negotiating, drawing up, enforcing, and monitoring contracts. In one of the earliest works on transaction costs, Coase (1937) argues that they are the main factor affecting a firm's decision of whether to vertically integrate, that being to bring a function that is adjacently positioned in the value chain in-house instead of procuring it on the open market. This means that a firm will decide to carry out a transaction within the firm once the price of doing so is less than in the open market. Furthermore, long-term contracts are pointed out as a way through which firms may reduce transaction costs.

Another central part of transaction cost economics is asset specificity. McGuinness (1991) describes asset specificity as the extent to which an asset or resource has a higher value in a specific transaction than in any other use. Highly specific assets have low value elsewhere (McGuinness, 1991), while assets with low specificity can be redeployed for different purposes and utilised without losing their productive value (Williamson, 1989). Asset specificity can take five general forms: site specificity, physical asset specificity, human asset specificity, dedicated assets, and brand name capital (Williamson, 1989). When transaction-specific investments are made, risks of hold-up problems arise, meaning that one party can threaten to withhold business (Grant, 2021). Riordan and Williamson (1985) argue that when asset specificity is high, it is more likely that a firm will decide to vertically integrate.

2.2.2.2 Resource-Based View of The Firm

The resource-based view is one of the most influential theories in management (Kraaijenbrink et al., 2010). This theory takes the stance that a firm's internal characteristics are the basis of competitive advantage (Barney, 1991). This internal view of the firm is a departure from externally-based models which argue that industry selection and positioning are the main focus of strategy (Grant, 2021). A firm's resources consist of the tangible and intangible assets that are semi-permanently tied to it (Wernerfelt, 1984). Viewing firms in terms of their resources can promote different insights from other views. A firm can identify which resources are likely to lead to profits and in turn base their strategy on the exploitation of key existing resources as well as the development of new ones (Wernerfelt, 1984).

Barney (1991) has developed a framework for identifying resources that may lead to a sustained competitive advantage. First, a resource needs to be valuable. Valuable resources are those that allow a firm to become more efficient and effective. Secondly, resources need to be rare. A firm can only enjoy a competitive advantage from a resource that is not common among a large number of firms. Third, the resource should be difficult to imitate. Lastly, the resource should not easily be substituted for other, equally valuable resources. A resource fulfilling all of these criteria may be referred to as a VRIS (valuable, rare, imperfectly imitable, and non-substitutable) resource. Once these criteria are met within a firm, it will have a higher chance of sustained competitive advantage. The VRIS model was further developed into VRIO, where non-substitutable was changed to organisation (Barney, 1995). However, this study will use the original VRIS framework.

2.2.3 Business Models

Despite its prevalence as a business term, there have been differing understandings in academic literature of what exactly a business model is (Casadesus-Masanell & Ricart, 2010; DaSilva & Trkman, 2014; Zott et al., 2011). Casadesus-Masanell and Ricart (2010) make an attempt at a definition, describing it as the way that a business operates and creates value for its stakeholders. In their literature review on the subject, Zott et al. (2011) present a number of different definitions, and most appear to agree with this, insofar as the term relates to the act of value creation and how it is done.

The *Business Model Canvas* is a model for describing the various aspects of a company's business model, including what value it offers to customers as well as what resources, activities and partnerships it employs in order to achieve this. Based on previous literature, Osterwalder (2005) identified and listed 9 main building blocks that can be used to describe a business model. This thus forms an adequate representation of the business model as a whole. These building block are often visually represented, as shown in Figure 2.2.

As explained by Osterwalder and Pigneur (2010), these 9 main building blocks are:

1. **Customer Segments**
   This is related to who the intended customers are. Defining traits include their needs, the channels through which they are reached, the relationships they require, their profitability as well as how much and for what they are willing to pay. Five types of customer segments are described.

   Mass Market refers to a situation where the focus is on one large group of customers that can be considered to have similar needs and problems, such as with the consumer market.

   Niche Market refers to a business model aimed at specific customer segments, where all aspects are tailored to fit the exact needs of this group of customers.

   Segmented refers to when the business model serves a number of market segments with needs and problems that differ somewhat. This involves modifying the value that is offered somewhat for each segment.

Diversified refers to a business model that serves two or more completely different customer segments. This means that an entirely different value proposition is offered to each segment. The reasoning for this could be a desire to leverage certain underused resources.

Multi-sided platforms refers to when a business model serves two or more customer segments whose interaction it is dependent on. An example given is credit card companies, who need both credit card holders and merchants who accept them.

2. **Value Propositions**
This is related to what value is offered to the customer. This includes what is being delivered, what problems are solved and what needs are met. This value can stem from the product or service being distinguished in a number of different ways.

Newness as a value proposition means that the value offered solves a problem or fills a need that customer has not previously been aware of, since there has never existed a similar offer.

Performance means that the value offered is centred around the product or service performing better than other available offerings.

Customisation is about tailoring the product or service to the exact needs of the customer. This is not only aimed at niche markets, as there are examples of products and services where mass market consumers have been allowed to customise and co-create.

"Getting the job done" is about filling a specific need for the customer, and alleviating them of the work associated with doing that job. An example that is brought up is Rolls-Royce's engine-as-a-service model, in which they manufacture and service jet engines for airlines, who pay a fee for every hour an engine is active. The airlines are thus relieved of the job of making sure that the engine is functional, and can focus on other matters.

Design is an aesthetic element that can make a product stand out. This is very important in the fashion and consumer electronics industries.

Brand/status refers to the social aspect of owning a product from a particular company and what that says about the customer. For example, some brands are used by customers to signify wealth, while others may offer status within a certain subculture.

Price refers to the cost of the product or service to the customer. Offering similar value as competitors, but at a lower price, is a way to appeal to customer segments that are price-sensitive. However, business models can also be specialised towards minimising expenses and providing a basic but acceptable customer experience in order to keep prices as low as possible. This kind of specialisation can also allow a wider market to access these products and services, if traditional offerings are prohibitively expensive. It is also possible to offer certain products and services for free.

Cost Reduction is about creating value through helping customers reduce their expenses.

Risk Reduction can be valuable to customers who want to avoid unexpected future expenses. An example of this that is given is offering a one-year service guarantee to someone buying a used car that may break down and need repairs.

Accessibility is about making products and services available to people to whom they would not previously be attainable, typically through innovations in business models or technologies. Examples given include part ownership of private jets and diversified investment funds, allowing people to take part in these despite not being excessively wealthy.

Convenience/usability in products and services can be a way to create value. An example of this is iTunes, which made purchasing music substantially more convenient than before.

3. **Channels**
   This is related to how the value proposition is communicated and distributed to the customer. This includes how customers are made aware of the product or service, providing ways for them to evaluate the value proposition, what choices customers have when it comes to choosing specific products and services, how the value proposition is delivered, as well as any customer support that is offered after the purchase has been made.

   Channels are divided into direct and indirect channels, as well as partner channels and own channels. Direct channels involve communicating directly with the customer, while indirect channels instead involve going through a third party. Partner channels are owned by third parties, while own channels are owned directly. Direct, own channels include *direct sales forces* and *web sales*, indirect partner channels include *partner stores* and *wholesalers*, while indirect, own channels include *own stores*.

4. **Customer Relationships**
   This is related to what kind of relationship the company has with its customers. The company may be focused on acquiring customers, retaining customers, or up-selling its existing customers. Additionally, aspects such as customer service and the amount of autonomy and influence the customer is afforded may be described here.

   Personal assistance is centred around human interaction. This means that the customer is able to get in touch with a real customer representative, before and after the purchase has been made. This can happen in person at the point of sale or via telephone, email, or some other means of communication.

   Dedicated personal assistance involves customers being assigned an individual customer representative. This can lead to deep, intimate relationships with customers. An example of this is having key account managers for especially important customers.

   Self-service involves no direct contact with customers. Instead, the customer is provided with all the necessary means to help themselves.

   Automated services can be described as a more sophisticated form of self-service that makes use of automation to personalise the experience somewhat. A typical example of this would be having customers make personal online profiles on a website, and then letting automated services make recommendations and offers based on their transaction history.

   Communities can be created to allow customers to interact with each other and exchange information to help each other with problems. This can also allow companies to become more involved with their users and gain insight into their demands and expectations.

   Co-creation is described as a way to go beyond the traditional relationship between a vendor and a customer, by allowing customers to co-create value. Typical examples of these include Amazon letting customers leave reviews of products or YouTube encouraging users to create their own content.

5. **Revenue Streams**
   This refers to the way that money is received by the business. A revenue stream is the value aspect that the customer ultimately pays for, and can follow different pricing mechanisms. Revenue models will be explored further in the next section.

Asset sale involves selling a physical product so that the customer then receives ownership rights to it. The customer is then free to use, resell or even destroy this product.

Usage fee refers to when the customer is charged for how much of a product or service they use. An example of this is a mobile network operator charging its customers based on how many minutes they spend on the phone.

Subscription fees involve selling continuous access to a service. An example given is gym memberships for which customers pay a recurring monthly or yearly fee.

Lending/renting/leasing involves charging customers a fee to receive exclusive rights to a product for a certain amount of time. This allows customers to make use of the product without having to bear the full cost of buying it.

Licensing involves selling the permission to use protected intellectual property for a fee. This allows the seller to generate income from owned properties without having to manufacture a product or provide a service. This is a common practice in the media industry as well as for patents.

Brokerage fees are generated by acting as an intermediary between two or more parties. Examples of this include credit card companies, who take a percentage of the value of each transaction made using their cards, as well as brokers and real estate agents who take a commission when they help a buyer find a seller.

Advertising of products, services or brands is another way to bring in revenue. This is common in the media and event industries.

Pricing mechanisms include fixed menu pricing and dynamic pricing. With fixed menu pricing, the price is determined based on static variables, while dynamic pricing is based on market conditions.

The following are examples of fixed menu pricing:

List price involves fixed prices for products, services and other offerings.

Product feature dependent pricing means that the price is based on the number or quality of the features included in an offering.

Customer segment dependent pricing means that the price is determined based on what customer segment is being served what characteristics it has.

Volume dependent pricing is determined as a function of the quantity that is purchased.

The following are examples of dynamic pricing:

Negotiation may take place between two or more actors to determine a price. This is affected by factors such as the negotiating power and skills of each actor.

Yield management involves the price being determined based on the seller's inventory as well as the time of purchase. This is typical for perishable resources such as hotel rooms and flight tickets.

Real-time-market pricing is determined dynamically, based on the supply and demand of the market.

Auctions may take place, in which the price is determined through competitive bidding.

6. **Key Resources**
   This refers to the resources required in order to deliver value, as well as to create and maintain relationships with customers. These can be owned, leased, or acquired from key partners.

   Physical resources include assets such as buildings, vehicles, machines, systems and distribution networks.

   Intellectual resources include brands, proprietary knowledge, patents, copyrights, partnerships and customer databases. These resources may be difficult to develop but can be very valuable.

   Human resources in the form of employees are always required to some extent, but there is a particular focus here on the knowledge and expertise of these employees. These resources can be very important in industries that are knowledge-intensive or require creativity.

   Financial resources include cash, lines of credit and stock option pools for employees. Ericsson is given as an example of a company leveraging financial resources, as they have been known to loan money from banks and capital markets and use some of it to finance their customers, in a practice known as vendor financing.

7. **Key Activities**
   This refers to the actions required to create and deliver value, reach the markets

that are being served, maintain relationships with customers, and earn revenue. Three main categories of key activities have been identified.

Production activities are those related to designing, making and delivering a product. This may be for the purpose of producing a large quantity of these products, or to ensure an especially high quality. For manufacturing firms, this is the most important kind of activity.

Problem solving activities are related to coming up with ways to solve individual customer problems. This typically requires activities such as knowledge management and training of employees. Consultancies and hospitals are given as examples of organisations dominated by these activities.

Platform/network activities are important for companies who have a platform as a key resource. Examples given of resources that can act as platforms are networks, matchmaking platforms, software, as well as brands. Examples of activities are managing, developing, maintaining and promoting the platforms as well as providing services.

8. **Key Partnerships**
This refers to the network of suppliers and partners that are needed to deliver value, as well as the nature of these partnerships. Three main motivations for creating partnerships are identified.

Optimisation and economy of scale is typically associated with basic forms of partnership and buyer-supplier relationships. It does not make sense for any one actor to own all resources or perform every activity on its own, and so these aspects are allocated to various actors in an optimal way. Partnerships formed out of this motivation are usually centred around reducing costs, and tend to involve outsourcing certain activities or sharing infrastructure.

Reduction of risk and uncertainty in a competitive environment can be achieved through partnerships. This can often be achieved through strategic alliances, where its members may cooperate in one area but compete in another. One example of this is Blu-ray, which was developed jointly by a number of electronics, computer and media companies, who then went on to sell their own competing products based on this standard.

Acquisition of particular resources and activities can be done through partnerships. It is unusual for companies to own every single resource or perform all the activities related to creating the value they deliver. Instead, their capabilities can be extended through outsourcing these aspects. This could also be borne out of a need for knowledge, licenses or access to customers.

9. **Cost Structure**
   This refers to the costs that are incurred when conducting business and delivering value. Business models can broadly be divided into two different types of cost structures. These should be considered extremes, with many companies falling somewhere in between in reality.

   Cost-driven business models are centred around keeping costs as low as possible. Costs are reduced wherever possible in order to be able to charge low prices. Automation is typically employed wherever possible, and much is outsourced.

   Value-driven business models are instead centred around creating value, with less consideration of the costs. This typically results in premium offerings and personalised service.

   Four main characteristics of cost structures are described:

   Fixed costs are costs that are unaffected by the volume of products or services that are produced. Examples of these are salaries, rents and physical manufacturing facilities.

   Variable costs are costs that are proportional to the volume of goods or services that are produced.

   Economies of scale are cost advantages, meaning a lower cost per produced unit, as a result of increased output. An example of this is that large companies buying products in bulk may benefit from lower rates.

   Economies of scope are cost advantages as a result of a larger scope of operations. An example of this is how large companies may use the same marketing activities and distribution channels to support several different kinds of products.

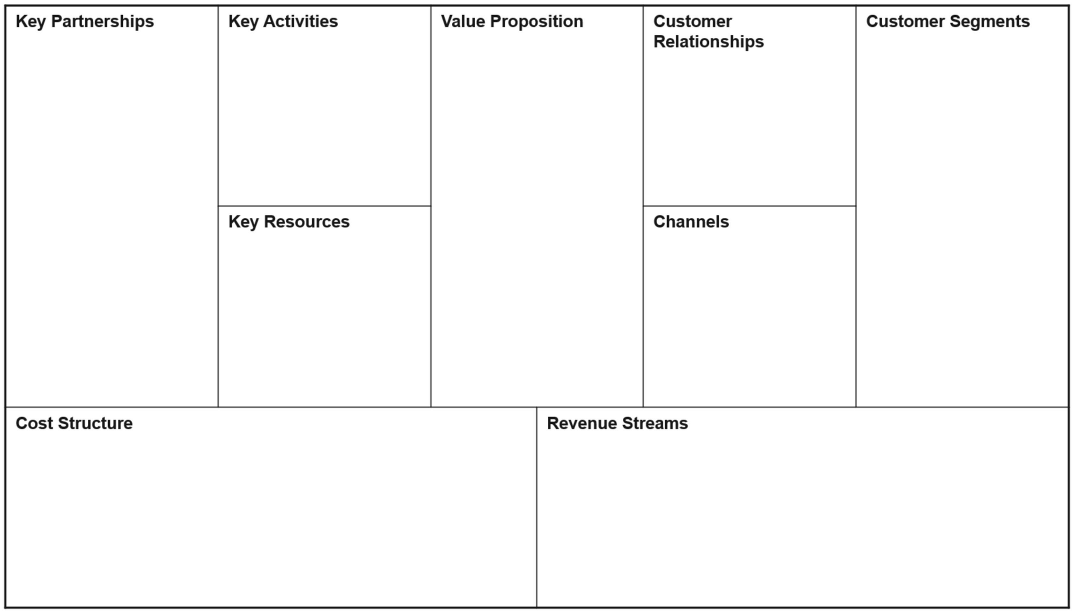

Figure 2.2: Business model canvas (Osterwalder & Pigneur, 2010)

Some criticism has been directed at this model. Lucassen et al. (2012) point out that it lacks detail when it comes to figures relating to costs and revenue, the exact nature of partnerships, and what the key activities entail, while Verrue (2014) claims that the fixed architecture of it can easily lead to a filling-in exercise.

However, this is the preferred business modelling tool among entrepreneurs due to how explicitly and accessibly it conveys all aspects of a business model, both tangible and intangible (Lucassen et al., 2012). This can include future business models (Fritscher & Pigneur, 2014b). Creating a business model canvas is typically done in groups (Fritscher & Pigneur, 2014a; Lucassen et al., 2012), and encourages the participants to engage with all aspects of it (Lucassen et al., 2012).

2.2.4 Revenue Models

Revenue models are core components of business models, as they explain how a company appropriates revenue from its customers through pricing structures (DaSilva & Trkman, 2014).

Enders et al. (2019) point out that the choice of revenue model may be determined by inherent characteristics of the service being provided, these being its pattern of usage and level of integration with a pre-existing product or service. The usage pattern may make certain revenue models more or less suitable. For example, a service that the customer only ever actively uses infrequently, but is continuously provided, such as an alarm system, may prohibit a pay-per-use model. Additionally, customers of a service that is highly integrated into another will expect the payment channels to be integrated as well. Related to this, Enders et al. (2019) note that providers generally prefer to use the same revenue model as they have used before, since they already have the required systems in place to support them, while customers typically expect certain revenue models to be in place, if they are common practice.

Different models all have different benefits and drawbacks, both for the sellers and the customers, and having a unique revenue model may in some cases be a competitive advantage (Enders et al., 2019). It is thus important to understand these concepts and consider them when designing a revenue model. In this section, a number of different revenue models are discussed.

2.2.4.1 Up-Front Payment

This is the model traditionally used for goods, in which the customer only pays for the product once at the start, and thus gains perpetual rights to it (Iveroth et al., 2013). Enders et al. (2019) bring up the fact that providers of services that require a large up-front investment are likely to seek short-term returns. For the seller, this model has the benefit of quickly covering these costs, but the drawback of not receiving continuous revenue, and for the customer, while the initial investment may be high, the product can be used potentially indefinitely, providing a lot of value (Ojala, 2013). A negative aspect for the customers is that any upgrades or maintenance needed will likely not be included, and so will cost extra (Ojala, 2013). Harmon et al. (2009) describe this as a dying revenue model for digital services, while Sato and Nakashima (2020) highlight it as highly attractive for customers of durable, physical products for which a high usage frequency is expected.

2.2.4.2 Subscription

This payment structure involves the customer making recurring payments in order to use a product or service within a set amount of time (Schüritz et al., 2017). For both the seller and the customer, it has the benefit of predictability, as the seller will know what their revenue and future cash flow will be, and the customer will be able to plan their expenses out (Enders et al., 2019; Ojala, 2013). Enders et al. (2019) emphasise how this may be suitable for companies offering services involving continuous expenses, regardless of usage.

For customers, Schüritz et al. (2017) and Tabares et al. (2023) bring up the prevalence of short-term subscription contracts, which offer flexibility. Any updates to the product are also likely to be included in a subscription, meaning that the value proposition may evolve throughout the time that the customer uses the product

(Iveroth et al., 2013).

Providers of basic digital services typically employ a subscription model (Tabares et al., 2023). Customers who are digitally inexperienced and do not wish to co-create value may find this model attractive, as it is simple, convenient and easy to understand (Enders et al., 2019; Tabares et al., 2023). There may also be cases in which the providers of the service do not have the required systems to accurately measure aspects such as usage or performance, and so are limited to this revenue model (Enders et al., 2019).

2.2.4.3 Pay-Per-Use

In this payment structure, the customer pays based on their usage of a product or service (Harmon et al., 2009), allowing them to use it without having to purchase a product. For sellers, this can lead to less predictable revenue streams if there is a lack of regularly paying customers, but the very accurate usage tracking that this revenue model typically requires may assist them in refining their pricing and other business processes (Sato & Nakashima, 2020).

This is a suitable model for customers who only intend to use the product on occasion, or for a specific purpose (Ojala, 2013). Additionally, the low cost of starting to use the product and the flexibility of being able to use it at any time can encourage a wide variety of customers to try it, meaning that the user base could potentially grow very large (Ojala, 2013). Enders et al. (2019) note how customers that are wary of financial risk may be especially drawn to this revenue model for this reason, and Bocken et al. (2018) suggest that pay-per-use models make consumers more conscious of how much they use a product. Sato and Nakashima (2020) point out that customers' expectations of how much they might use a given product often may determine whether they decide to buy a product outright or use a pay-per-use service.

Tabares et al. (2023) note that customers who desire added customisation and more sophisticated services may prefer a usage-based model. This model and the subscription model are both identified as appropriate for one-to-one relationships between companies with little interaction with other actors in the value network, noting that pay-per-use is especially apt when the customer desires higher added value. They may still be appropriate when other actors are involved, especially when the customers are unaware of their digital needs or are unable to support a more sophisticated service. Schüritz et al. (2017) point out that many subscription models may incorporate aspects of usage-based payment by offering different tiers.

2.2.4.4 Performance-based model

In performance-based models, sometimes known as gain sharing (Schüritz et al., 2017), compensation is based on the outcome of the service provided (Schüritz et al., 2017; Tabares et al., 2023). Tabares et al. (2023) note that performance-based models are typically used for advanced digital services and tend to include metrics related to problem resolution and contingency responses.

Service-level agreements (SLA), an example of a performance-based model, are contracts between a provider and a customer wherein the Quality of Service (QoS) of the provided service is guaranteed at a certain price (Lee & Lee, 2007; Zubilevich et al., 2021). In a network context, QoS is determined by metrics such as packet loss, throughput, latency, jitter, availability and more (Rouwet, 2022). SLAs typically outline service-level objectives, which are specific aspects of the service for which penalties may be incurred by the provider if QoS is not to the right standard (Schulz, 2011). Fulfilment of these objectives must be based on clearly defined metrics, with contracts usually outlining how they are to be measured, as well as how this information is to be communicated (Zubilevich et al., 2021). Measuring and following up on fulfilment of objectives is a major aspect of any SLA (Gutierrez Fernandez, 2015).

Zubilevich et al. (2021) state that SLAs can be beneficial for both the provider and the customer, given that the customer is willing to pay extra for a high QoS. For the provider, they lead to increased income, and for the customer, they act as an insurance. Performance-based models may be attractive to customers who wish to share the risk with the provider (Enders et al., 2019; Tabares et al., 2023). However, even with clearly defined contracts, customers may require a certain level of trust to have been established with the provider before entering into such agreements (Enders et al., 2019).

Sharma et al. (2023) point out that it is possible for multiple actors to collaboratively provide a service and create a multi-party SLA. This is echoed by Tabares et al. (2023), who describe performance-based models as appropriate for situations in which value is created by an ecosystem of actors collaborating and coordinating to a large extent, thus representing a higher risk.

2.2.4.5 Tiered Pricing

Tiered pricing involves selling different version or packages of the same product at different prices (Mohammed, 2005), and can be combined with any of the aforementioned revenue models. In evaluating this model's benefits and drawbacks, Mohammed (2005) points out that for the seller, it is beneficial in that it allows them to capitalise on customers with high or low valuations of the product, potentially gaining a lot of new customers. It is also identified as relatively cost-effective, as any additional features will typically not cost as much to develop as the core product. The drawback is that low-priced versions run the risk of cannibalising sales of the higher-priced versions. The customer benefits from the flexibility of being able to choose how much they want to spend on the product.

3

Method

The following chapter presents the methods used in the study. First, the research approach is presented, followed by a presentation of data collection, sampling, data analysis, and research quality.

3.1 Research Approach

The aim of this study is to develop forward-looking value networks and business models for the selected use cases based on the findings from the analysis of the data. This approach is in line with the inductive research approach, which, as defined by Bell et al. (2019), involves making generalisations out of observations, as opposed to the deductive approach of using current theory to test hypotheses. Additionally, the study employs a qualitative research methodology, relying on words and patterns rather than quantification in data collection. This research strategy is well suited for an inductive study of this nature (Bell et al., 2019).

3.2 Data Collection

Data collection was conducted using four main types of data sources, in order to best achieve a comprehensive understanding of the subject. Triangulation, in this case the use of multiple qualitative data sources, can greatly increase the confidence in the final results (Patton, 1999). For this study, the following data sources were used: (1) semi-structured interviews, (2) focus group discussions, (3) academic literature, and (4) documents. Data collection from these sources were collected on a continuous basis.

Semi-structured interviews conducted over video calls were the most prominent data source. The advantage of using semi-structured interviews is the flexibility it affords (Bell et al., 2019), as each interview does not have to follow the exact same structure. In semi-structured interviews, a number of key questions define areas to be explored, but the interviewer or interviewee may diverge in order to explore an idea in more detail (Gill et al., 2008). An interview guide (see Appendix A) was prepared prior to the interviews. Owing to the exploratory nature of the research topic, it contained a number of general topics to be covered, which were communicated to the interviewees in advance. Based on current needs and the interviewees' expertise, relatively open-ended questions were asked at the start of interviews, in order to yield as much information as possible (Gill et al., 2008), with questions getting more specific as the interviews developed and went in different directions. As Bell et al. (2019) note, questions in interview guides do not have to be followed exactly as outlined, and additional questions may be added based on the responses of the interviewees. Transcription is an important part of data collection in interviewing for reducing bias and providing a permanent record of the interview (Gill et al., 2008). Therefore, the interviews were recorded and subsequently transcribed.

Additionally, visuals were used during interviews. The use of visuals in qualitative research can be an effective way to gain richer data by promoting participant engagement and communication (Pain, 2012). Interviewees were asked to discuss actors and roles in each use case. A visual was used where actors were sketched out based on the participants' responses. This practice gave each interviewee an overarching image of all actors, facilitating deeper reasoning and gathering of data. Interviewees were encouraged to speak about what they found interesting or relevant, often leading to tangents highlighting not previously considered aspects and perspectives relating to the value networks.

Focus group discussions involved the gathering of domain experts to discuss the research topics. Gill et al. (2008) highlight that focus groups can be useful to include in a multi-method design to explore a topic or collect a group narrative, as well as to extend or challenge data collected through other methods. The focus group method is also a good way for participants to challenge each other's views and formulate creative ideas together (Bell et al., 2019). As the topic of integrated TN and NTN is new and emerging, the creative aspect of the focus group method was desirable. Focus groups were conducted as focus group discussions, facilitating interactions among participants as well as with the moderators, as opposed to focus group interviews, which place less emphasis on discussion between participants themselves (Boddy, 2005). For this study, focus groups were mainly used to generate new creative ideas and to validate previous findings. To encourage rich discussions, similar visuals were used for the focus groups as in the interviews. While researchers can choose their level of involvement in focus groups (Frey & Fontana, 1991), for the purposes of this study, the researchers took a more active role in order to keep the group on track, as well as to share findings and insights from previous data collection and analysis. The same topics were used to guide the discussions as in semi-structured interviews.

Academic literature, with a preference for recent studies, was used as a reference for both use cases. This was done in order to ensure a good foundation of data and a firm understanding of the subject. Insights from the literature acted as a complement to the semi-structured interviews and focus group discussions, informing the discussions and providing further findings with which to iterate the synthesised models. Conversely, the choice of literature was also informed by the interviews, the findings of which served to highlight new topics to explore.

Documents were also used as sources of data. While many types of documents can be used in qualitative research (Bell et al., 2019), this study mainly made use of public documents, such as white papers and websites from commercial ventures and startups intending to enter the researched industries, as well as news articles.

3.3 Sampling

Purposive sampling was used for this study, a method that involves selecting units that are directly relevant to answering the research questions (Bell et al., 2019). More specifically, this study employed a theoretical sampling approach, where instead of being a single separate stage, data collection was an ongoing process of refining emerging theoretical categories (Bell et al., 2019). Srivastava and Hopwood (2009) emphasise that an iterative approach, characterised by deep reflexivity, wherein emerging insights shape the direction of subsequent data collection and analysis, proves highly effective for generating insights in qualitative research. This iterative approach to data collection and sampling was considered appropriate, given that the topic of the research was highly exploratory in nature. Knowledge gaps relating to certain aspects could then be filled by selecting data sources and altering interview questions based on the specific need.

This study was conducted in collaboration with Ericsson, a global provider of telecommunications equipment and services. This was a good setting for the purpose of this study, as it ensured access to interviewees who were highly knowledgeable in the research topic. Interviewees consisted of people with both a technical expertise as well as people that were more business-oriented, ensuring a holistic view of the topic. In addition to Ericsson employees, external people were also interviewed. These were selected based on their research or work focus being closely tied to the topic and their willingness to participate. Following an iterative approach, some interviewees were interviewed multiple times in order to delve deeper into previous responses or expand into new topics of interest. Read (2018) refers to the use of a single interviewee multiple times as serial interviews, and notes that traditional one-and-done interviewing builds on the assumption that the information desired by the researcher exists and is relatively straightforward to conceptualise and understand. However, in this study, the topic is highly exploratory in trying to develop future scenarios. This calls for interviewing to be conducted in a way that allows for key topics to be probed from multiple angles. Read (2018) also highlights that in certain projects, the use of *critical informants* who are uniquely well positioned to shed light on specific topics can be of great value. This was the case in this study, where certain people who were especially knowledgeable on the topic were interviewed several times. In total, twelve interviews were conducted with nine different interviewees, which can be seen in Table 3.1.

Table 3.1: List of interviewees

Interviewee	Role	Date	Duration
1	Researcher	2024-02-24	94 min
2	Business Development Director	2024-02-28	56 min
3	Strategy Director	2024-02-28	59 min
4	Business Area Head	2024-03-15	60 min
5	Sales Engagement Director	2024-03-15	60 min
3	Strategy Director	2024-03-19	60 min
1	Researcher	2024-03-20	54 min
2	Business Development Director	2024-03-26	45 min
6	Master Researcher	2024-03-27	57 min
7 & 8	Employees at the Swedish Transport Agency	2024-04-05	60 min
9	Principal Researcher	2024-04-09	67 min
3	Strategy Director	2024-04-10	62 min

(Bell et al., 2019) recommend familiarising oneself in the work environment of one's interviewees in order to better understand them. Prior to the interviews, the researchers spent time at Ericsson's office, acquainting themselves with the environment, corporate culture and frequently discussed subjects. This facilitated the interviews, in particular those with Ericsson employees, as it served to instantly create a sense of familiarity and common ground.

Participants for focus groups were selected from within Ericsson. One of the key factors for successful focus groups is interaction, and one of the best ways of achieving this is the use of groups who are already familiar with each other, as they have shared experiences and can feel comfortable discussing with each other (Gill et al., 2008). The participants in the focus groups had previous experience together, which facilitated discussion. They were also involved in the individual interviews, which meant that they were already aware of the research topic and the purpose of the study. Gill et al. (2008) suggest that the optimum number of participants for a focus group is six to eight, while noting that success can still be had with other sizes. For this study, focus groups consisted of seven to eight individuals, which was a good size to ensure many points of view, while not being too large. Typically, 12 to 15 focus groups are desirable, although some studies use significantly less (Bell et al., 2019). However, since this study used semi-structured interviews as the main source of data, and focus groups as a supplementary source of data to gather group insights and validate previous findings, only two focus groups were conducted. The conducted focus groups are presented in Table 3.2.

Table 3.2: Focus group discussions

Focus group	Participants	Date	Duration
1	7	2024-02-28	87 min
2	8	2024-04-18	90 min

Academic literature was first selected based on a systematic search. Articles that referenced anticipated business models, stakeholders, or similar topics with regard to the specific use cases were gathered, mainly from the academic databases Scopus and IEEE Xplore. Articles were selected based on how relevant their titles and abstracts were to the research questions. Additional literature was collected through snowballing and subsequent literature searches to gain a more comprehensive view and fill gaps in data.

Documents were also used as a source of data. These included company white papers, news articles, and more and were selected purposively.

3.4 Data Analysis

Thematic analysis is a common approach in qualitative research (Bell et al., 2019) and was used in this study. It offers a way to organise, analyse, and interpret data to generate overarching themes (Clarke & Braun, 2017). In this study, relevant data from focus groups, literature, and documents were used to develop themes. Using the constant comparative method described by Glaser (1965), the themes and data were then continuously compared, updated and revised when appropriate. This was to ensure a close connection between findings and data.

3.5 Research Quality

This section discussed the quality of the research method used for this study. Mainly, the validity of the findings is discussed, specifically the criteria of credibility. Then, ethical considerations are considered.

3.5.1 Validity

There are several ways to assess the quality of qualitative research. Bell et al. (2019) provide evaluation criteria for qualitative research which includes credibility, transferability, dependability, and confirmability. Owing to the forward-looking nature of this research, the question of credibility is identified as being the most important and will be discussed further.

Credibility in qualitative research refers to whether the findings of the research present an accurate view of reality (Bell et al., 2019). Several techniques have been used to increase credibility in this study. Firstly, triangulation has been used as a method of data collections, using findings from interviews, focus group discussions, academic literature, and documents to build a holistic view of the research topic. Second, one of the purposes of focus group discussions has been to validate findings among the respondents, a practice referred to by Bell et al. (2019) as respondent validation. Third, at the end of the research project, the results of the analysis were presented to a panel of industry actors. The panel consisted of participants from telecom vendors, mobile network operators, aviation companies, universities, and more. In total, 16 panel participants were present. Following the presentation, panel participants were asked to provide oral feedback. They were subsequently asked to provide written feedback following the discussion should they have further realisations.

One threat to credibility is the fact that respondents in interviews and focus groups discussions mainly consisted of Ericsson employees. This might provide a bias where respondents mainly present the perspectives of a telecom vendor. This weakness has been mitigated through methods of triangulation, inclusion of research professors in interviews, and feedback from a panel of multiple industry actors.

3.5.2 Ethical Considerations

Diener and Crandall (1978) highlight four main ethical principles in business research; whether there is harm to participants, lack of informed consent, invasion of privacy, or deception. The research topic is not deemed to be sensitive with regard to respondents' informed consent, harm to participants, or potential deception. Respondents were informed before interviews that they would be anonymous in the report to protect their privacy. Sensitive information that the researchers received from Ericsson was handled with great care. No confidential information has been publicly disclosed.

4

Empirical Results

4.1 Connectivity for Rural and Remote Areas

The following section will outline the empirical findings related to the case of connectivity for rural and remote areas.

4.1.1 Conditions

This section presents empirical findings concerning the industry conditions associated with the emerging use case for direct-to-device NTN connectivity. It encompasses technical conditions and the roles of various industry stakeholders involved in the use case.

4.1.1.1 Technical Conditions

Several interviewees alluded to the increasing interest in the NTN connectivity space, both from industry players and consumers.

> *"NTN has been a hot topic for the past couple of years. There has been standardisation in 3GPP for this and there have been work items to add support for NTN in 5G."*
>
> \- Interviewee 6

One of the fundamental questions regarding the direction which this use case will develop is which standards will be used. While there has been work in the 3rd Generation Partnership Project (3GPP) to include NTN, there are still several possible tracks being explored by industry players in providing NTN connectivity direct-to-device. There are examples of companies trying non-3GPP solution, including unmodified LTE and proprietary solutions. Unmodified LTE does not rely on any new functionality in devices, but rather uses standard LTE for satellite connectivity. The problem with this solution, which does not use satellite spectrum, is that there are interference concerns with terrestrial networks. In the proprietary track, there are different solutions being explored, but they do not adhere to any standards. Although some companies have experimented with solutions that are not compliant with 3GPP, interviewees seem to be in agreement that in a future mass-market scenario for NTN connectivity, standardised solutions will be required to reach the vast device ecosystem.

> *"There is the 3GPP, the proprietary NTN, and unmodified LTE path. [...] What we're looking at ahead here is hundreds of millions of users. Then these don't scale, the proprietary solutions."*
>
> \- Interviewee 5

Interviewees also highlighted several drivers behind the 3GPP route becoming dominant for direct-to-device NTN services. Several industry players may benefit. SNOs will gain access to a mass-market of NTN capable devices. Manufacturers of wireless chipsets for phones and other devices may find new revenue opportunities in selling NTN capable chips to device manufacturers. Telecom vendors, who traditionally have sold network infrastructure to MNOs and MVNOs, are likely to support a 3GPP solution, owing to their existing products and expertise.

There is also a discussion as to which architecture will be used for future satellites. Different architectures offer different levels of intelligence in the satellite. As discussed by several interviewees, the main architectures are transparent, semi-transparent, and regenerative architecture. One interviewee provided an in-depth explanation of the different architectures. In the transparent architecture, the ground serves as the primary hub and the satellite acts as a repeater. This architecture is highly suitable for GEOs, particularly for the traditional SNOs. Due to their operational lifespan ranging from 20 to 30 years, this architecture allows upgrades to the technology to be made several times during the satellites' lifetime.

Currently, the hype is behind the LEO constellations. For these satellites, the fully transparent architecture does not really scale well. In such setups, analog signals are transmitted from the ground, converted to digital, relayed through the satellite, and then reconverted to analog, resulting in multiple conversions that are best avoided. Conversely, regenerative architectures enable direct transmission of digital signals, minimising the need for such conversions. In the regenerative architectures, there are different options. One option in 5G is to have the full base station (gNodeB) onboard the satellite. Another is to only have the radio onboard and keeping the rest on the ground. Future LEO constellations will settle on some of these architectures but it will depend on the use case. The fully regenerative ones have the least latency. Every addition to the satellite is costly, and so unless it is required, SNOs may opt for a semi-transparent architecture that would just have the radio onboard.

"Unless [a fully regenerative architecture] is required, it is more likely that SNOs will choose a semi-transparent architecture."

- Interviewee 6

4.1.1.2 Role of MNOs

Interviewees agree that MNOs are likely to be the ones who will take the customer facing role in the provisioning of NTN connectivity, rather than other actors such as the SNO. The main reason behind this is that MNOs already have a large number of subscribers, so by adding the NTN connectivity service to their current offering, they have the strongest go-to-market channel. Furthermore, MNOs already have a presence on local markets and are aware of all regulatory aspects.

"What you want is to have only one subscription. And use TN and NTN when needed. [...] MNOs are a go-to-market channel. They are well-known. [...] They already have the customers locked in. So essentially, it's the customer base and brand that are their key resources here, and then sales and marketing, of course. Obviously, they have a terrestrial network and spectrum, which is relevant when you have a combined service. [...] You'll use NTN so little that you won't buy a separate subscription for it, but you want an MNO subscription that includes it."

- Interviewee 3

There are also drivers that point towards MNOs seeing this kind of connectivity as a good business opportunity, which has been explained by interviewees. First of all, it is an opportunity for them to differentiate themselves. If an MNO is able to offer a connectivity service even in rural and remote areas, they can gain a competitive edge against competitors. Second is the fact that there may be regulations requiring MNOs to provide a certain level of coverage even in remote areas. By utilising NTN connectivity to expand coverage, they are able to reduce the need for physical infrastructure required for building out terrestrial networks. This then becomes a way to minimise costs. In some cases, the MNO might not have to make any significant investments on their own to offer this service.

"MNOs want to differentiate themselves."

- Interviewee 5

4.1.1.3 Role of SNOs

Satellite network operators operate satellites and have access to satellite spectrum. One major topic of discussion with the interviewees was the role that SNOs traditionally have had, and the role that they will play in the future. Traditionally, SNOs have provided a relatively basic service, in which their satellites have simply acted as relays for the data that their customers, mainly TV channels, have wanted to transmit. There has typically been little to no processing or handling of this data done by the SNO, with interviewees referring to this practice as wholesaling capacity.

> *"Terrestrial and satellite operators may seem similar, just that the satellite operator has an antenna higher up. But in reality, this is not the case, at least not at the moment. Satellite operators are more pushed back."*
>
> \- Interviewee 3

The reason SNOs are more pushed back stems from their legacy business of wholesaling radio capacity. They have no experience in providing a service such as direct-to-device connectivity. This has given SNOs a relatively weak position in the market, not being able to appropriate much of the profits from the overall value chain that they are enabling. Furthermore, several note that the legacy TV business of the SNOs is in decline due to the rise of streaming services. This makes them eager to exploit new business opportunities. In comparing terrestrial and satellite operators, one respondent stated the following:

> *"Terrestrial operators often make more during the lifetime of a phone than what the phone costs. They are very strong. But satellite operators barely make any money at all. [...] They basically just sell raw radio capacity."*
>
> \- Interviewee 3

Based on the satellite operator business being historically weak, several interviewees point out that direct-to-device NTN connectivity opens up a lucrative opportunity for SNOs. A potential mass-market scenario where billions of devices are able to use satellite connectivity opens up a vast device ecosystem for SNOs to exploit. However, what still remains uncertain is what the business case is and how the SNOs should position themselves. To provide a seamless service to end-users through MNOs, there needs to be a core network for satellite connectivity and a roaming interface between the terrestrial and satellite network. Someone needs to build a cellular network that is able to handle messaging, voice, and data services for the satellites to be able to provide a roaming interface. In response to a question on what SNOs currently do and what needs to be established to offer the NTN service, one interviewee stated:

> *"If you just have antennas, you don't have a service. You need a business support system, core network, user database, and so on to have a service."*
>
> \- Interviewee 3

The satellite network and roaming interface that need to be established has been the topic of much discussion during interviews and workshops. There is uncertainty on who will actually build out these capabilities and enable the service. Skylo is a company that has identified this need for a middle-layer between the MNO and SNO, and built out a network service themselves which is predominantly aimed at IoT, utilising existing satellites. Interviewees were doubtful that this could be the start of a trend wherein this middle-layer role gets be taken on by entirely new actors. Some believed that SNOs are likely to develop these capabilities themselves and build a network and services that can be directly integrated with MNOs. Since they have access to the satellite spectrum, they have an advantage over other actors in deciding which role they want to play. However, MNOs and device manufacturers were also identified as players who might seek opportunities in this space.

> *"It's like a battlefield that SNOs, MNOs, and device manufacturers might want to conquer."*
>
> \- Focus group participant

While many interviewees expressed uncertainty about future likely outcomes, some were more certain in seeing SNOs taking over the role as a main scenario in the future. SNOs would then be in direct contact with MNOs.

> *"Skylo has found this niche for themselves. But I would think that SNOs want to go directly to the MNOs. I wouldn't expect too many more Skylo's in the future."*
>
> \- Interviewee 6

Some also alluded to the possibility that MNOs might want to play a larger role in this business.

> *"There might be ambitions from MNOs to advance in this value chain."*
>
> \- Interviewee 5

Another topic of interest for several interviewees was the size of the investments in satellites for SNOs. Creating new LEO constellations requires large investments in satellites and launching them. SNOs will therefore be eager to exploit all opportunities they can with their LEO constellations to recover large CAPEX investments.

4.1.1.4 Roles of Other Actors

Imagining a 3GPP scenario, interviewees brought up the importance of the compatibility of devices in an NTN service. User equipment sold to users need to be compatible and standardised. Standardisation work is a collaboration between device manufacturers, chipset manufacturers, and telecom vendors. Interoperability development testing (IODT) as described by interviewees a process of testing between these players to ensure different components and interfaces can interact correctly. A further collaboration that might be necessary is the collaboration between telecom vendors and satellite equipment vendors to ensure efficient working between their components, especially in the case of semi-regenerative architectures where there is a radio onboard the satellite and baseband unit on the ground.

Discussions also highlighted the business of the SNO. They have three main costs: ground equipment, satellites, and launching. Ground equipment consists of gateways, data centres, and other surrounding equipment. The satellite consists of a satellite frame, payload, and solar panels. Lastly, a major cost for SNOs traditionally has been launching costs. However, with improvements in the Falcon rocket family from SpaceX, launch costs have come down dramatically.

4.1.2 Current Developments

Companies are already working towards connecting mobile users in remote areas, and some niche solutions already exist. Some notable ones which were brought up by several interviewees are Starlink, Apple, and Skylo. However, the implementations of these services are limited and differ somewhat.

In the case of **Starlink**, they offer a direct-to-device messaging service through their constellation of LEO satellites. In the US, they have partnered with **T-Mobile** who offer the service to their customers. Through this partnership, Starlink can use T-Mobile's terrestrial spectrum on their satellites to connect to mobile phones. Customers can use their phone as usual and when they are out of reach from the terrestrial network, their phones roam onto Starlink's network. Starlink is in this case dependent on T-Mobile's spectrum for terrestrial coverage. If they wanted to offer this service directly to customers without an MNO, they could produce their own SIM-cards but they would be limited to satellite connectivity.

> *"Starlink have built everything so that they are on par with the MNO and can provide a roaming interface."*
>
> - Interviewee 3

In the case of **Apple**, they have partnered with a satellite operator, **Globalstar**, to provide emergency SOS in new iPhones. As described by interviewees, this service is an emergency messaging solution and does not involve voice, data, or messaging, but only geographical coordinates in case of emergency. It does however, provide an interesting example of device manufacturers collaborating directly with satellite operators to provide an NTN service.

Skylo is an interesting player that has emerged in the NTN space. Several interviewees talked about the business model of Skylo. The company has partnered with IoT connectivity providers such as Emnify to add satellite connectivity to these services. Skylo collaborates with SNOs, and through their own 3GPP RAN and core network, they are able to provide the service to customers. They have built out their own base stations at the ground stations of SNOs, and the SNOs wholesale capacity to them. Skylo has thus built a middle layer so that satellite networks can interoperate with TNs.

4.2 Autonomous Flying Taxis

The following section will outline the empirical findings related to the case of autonomous flying taxis.

4.2.1 Conditions

This section presents empirical findings concerning the industry conditions associated with the emerging use case for connectivity for autonomous flying taxis. It encompasses requirements on connectivity links and the coordination of flying taxis in the air.

4.2.1.1 Customer Experience

The general consensus among interviewees was that the flying taxi service would function similarly to existing ride-sharing services. Passengers would use some kind of app or website to book flights. They would then fly between special landing platforms for flying taxis, known as vertiports. It is likely that vertiports will also host infrastructure for flying taxis to charge and dock (Rajendran & Pagel, 2020).

4.2.1.2 Connectivity Requirements

Several interviewees agreed that autonomous flying taxis will have strict connectivity requirements. The main aspects that were brought up were the needs for strong wireless connections, as well as for these connections to be continuously maintained throughout the flight.

In their study on communication technologies for UAM, Bae et al. (2022) identify several requirements for UAM communication. These include:

1. **Robust Command and Control links**
   Wireless Command and Control links between base stations and UAVs should be robust, and link recovery must be fast if the link is broken.

2. **Communication support at UAM operational altitude**
   The communication system needs to support UAVs travelling at altitudes between 300m and 600m. When using the terrestrial network, this will require either tilting antennas up towards the sky or installing new antennas to ensure coverage.

3. **High-speed mobility in air space**
   The average speed of these aircraft is expected to reach 330km/h or more. The communication system needs to be able to cope with signal failures such as Doppler transitions.

4. **Precise location information**
   To avoid collisions and ensure safe flight in air corridors, location information at the cm level for the flying taxis will need to be continuously gathered.

5. **Interference control and management**
   Communication between high-density UAVs and terrestrial networks can cause interference to neighbouring base stations and users on the ground. This interference needs to be properly managed and controlled.

6. **Strict conditions of loss and latency**
   To ensure safe operations, there will be high requirements for loss and latency.

Interviewees agreed that connectivity would most likely need to be provided by both TNs and NTNs. NTNs were considered necessary since flying taxis may fly in areas where TNs do not have coverage. One interviewee also brought up the need for redundancy in the connections, which NTNs could provide.

Interviewees were generally of the understanding that for TNs to provide this kind of connectivity, antennas would need to be pointed up into the sky. Bae et al. (2022)

illustrate how this could go some way to provide the necessary coverage in the sky, at the expense of some areas on the ground. New equipment would certainly include new antennas on existing telecom towers, but as one interviewee suggested, there is also potential for them to be placed on vertiports. Another interviewee suggested that beamforming technology could be a potential alternative to this.

As for the wireless technology on the actual flying taxis, several interviewees pointed to the fact that currently active drone manufacturers do not typically buy chipsets enabling connectivity directly from their manufacturers. Rather, they purchase components, known as gateways or modules, that already have these parts installed. As with the chipsets required for the previous use case, interviewees agreed that interoperability testing would be required between telecom vendors and the chipset manufacturers to ensure that the networks deployed and the flying taxis were compatible.

One major technological challenge discussed by several interviewees was that of ensuring continuous connectivity throughout the flight, necessitating what is known as seamless handover. A flying taxi that is about to leave the area of coverage of one base station must already have established a strong connection with the next one. Colpaert et al. (2020) suggest that UAVs will experience 1-10 such handovers per minute. Additionally, several interviewees pointed to the fact that most MNOs lack sufficient network infrastructure to provide coverage for a flying taxi service on their own, suggesting a potential need to use the networks of several operators.

There were different suggestions among the interviewees for how this could potentially be solved. The presence of MVNOs specialised in the IoT sector was brought up, with these companies providing SIM-cards with favourable roaming agreements in many different countries. In general, IoT was seen as a highly comparable sector to AAM and flying taxis.

> *"Flying taxis are IoT devices, put simply."*
>
> - Interviewee 4

However, as flying taxis are likely to operate domestically to a large extent, the fact that national roaming is forbidden in many countries was brought up as a potential hindrance to this solution. One interviewee brought up an example of a truck company that uses Danish SIM-cards in Sweden in order to roam freely among Swedish MNOs, thereby circumventing this regulation. Another interviewee pointed to the existence of modules that contain multiple SIM cards, allowing the flying taxi to connect to several TNs as well as an NTN.

> *"In their current form, they have multiple SIMs in them. And it's got a smart algorithm in those modules. And they are currently used in flying taxis or bigger drones. So these modules keep scanning for the availability of good TNs. Then it switches, or latches on to that specific mobile operator. If the coverage is not good enough, then there's a backhaul, the satellite is already there. So these modules are already available on the market. On a constant basis, real time, the algorithm does this analysis and sees 'What's my best connectivity?'. So that's a very crude form of connectivity currently. Ultimately, we would want them to be integrated in the [software development kit] of a flying taxi."*
>
> - Interviewee 4

Several interviewees did not believe that simple roaming like this would provide a sufficiently reliable connectivity service, as there could be gaps in connectivity between base stations. One interviewee instead suggested that staying within a single network would more effectively facilitate seamless handovers.

> *"But if you want to have really seamless connectivity, then you don't want to switch from one operator to the next one all the time. You just want to stay with one operator, and do a proper handover between cells and so on. And so, I mean of course you could set up these really seamless handovers even between operators, but that would need some cooperation between the operators then."*
>
> - Interviewee 6

Several interviewees agreed that it was likely that some kind of aggregation of multiple network operators into one service would be necessary to provide the required connectivity. As with the case of the roaming interface, just who might take on this aggregating role was the topic of some discussion. It was considered possible that an MNO could attempt to step up and provide this service, or that actors already providing services related to air traffic management to drone operators could add this to their suite of services. A dedicated third party akin to an MVNO was another potential outcome.

The prospect of a third party coordinating and ensuring connectivity among several different operators, and how to achieve this, was much discussed. It was believed that dedicated network infrastructure, such as a core network, could potentially be used to coordinate seamless handovers. Interviewees also thought that the companies operating the flying taxis would need to provide information on routes ahead of each flight, in order for this actor to ensure that the connectivity along the way would be sufficient, and not overloaded.

It was acknowledged that selling a service that is so heavily dependent on performance, without actually owning or directly operating the related infrastructure would be difficult. It would thus require the establishing of strict agreements with the network providers, with performance-based pay. It was suggested that SLAs with KPI-based penalties could be suitable for this.

Interviewees were unsure of the role of HAPS, only believing that they may play a part under special circumstances.

4.2.1.3 Coordination of Flights

Different traffic management systems for UAVs are being developed and used around the world. In the US, NASA has developed a system called UAS Traffic Management (UTM), and in the EU, the system is called U-Space (Shrestha et al., 2021). However, these currently only account for very low-level airspace (Shrestha et al., 2021), and they will need to be greatly expanded and updated in order to be able to support and manage future AAM use cases. One interviewee pointed out that there currently does not exist any U-Space airspace outside of some examples where it has been established for research purposes in Belgium, the Netherlands and Spain.

Interviewees elaborated on the structure of U-Space. Key roles will include the Common Information Service Provider (CISP), U-Space Service Provider (USSP), and the governmental authority. USSPs as well as CISPs will require certification from the governmental authority in order to be allowed to operate in this sector.

The CISP will provide general information about weather, airspace conditions and more.

> *"Exactly, it'll be information on the structure of airspaces, both static and dynamic. Temporary rules, limitations, and so forth. Information about all kinds of things, basically."*
>
> - Interviewee 7

In most European countries, these responsibilities will be centralised. For example, the Swedish Civil Aviation Administration will be the sole CISP in Sweden. However, U-Space does allow for these responsibilities to be divided up among different actors too (Swedish Transport Agency, n.d.).

Interviewees brought up the fact that USSPs will be required to provide four services to companies operating UAVs. These include a *network identification service*, in which the identity of UAS operators and drone locations and trajectories are provided, a *Geo-awareness service*, in which information on operational conditions, airspace limitations and time restrictions are provided, a *UAS flight authorisation service*, which ensures that operations do not conflict with those of other UAS operators in the same airspace, and a *traffic information service*, which alerts UAS operators of surrounding air traffic (European Civil Aviation Conference, 2021).

One interviewee said that private companies will act as USSPs, and that there will be a free market associated with these services. However, any operators of flying taxis or other AAM services will be required to use the services of a certified USSP. USSPs will be free to provide additional services on top of the ones listed, and they will not be prohibited from outsourcing aspects of their services.

Interviewees pointed out that there is currently no payment system in place when it comes to air traffic management for UAVs. However, one interviewee brought up the fact that for traditional air traffic, the fee that airlines pay is typically based on the distance flown, and suggested that that could become the case for AAM as well. Another interviewee mentioned that air traffic management in different air spaces may charge differently, sometimes leading airlines to choose to take a longer route in a cheaper air space in order to make the overall cost of the flight lower.

Shrestha et al. (2021) have developed an architecture for an advanced unmanned aerial vehicle traffic management system that takes into account future UAVs operating at higher altitudes as well as the integration of TN and NTN. Two main roles are attributed to the UTM System: urban airspace segmentation and airspace traffic management. Urban airspace segmentation entails that airspace is divided into a multi-dimensional map. The UTM System monitors airspace requirements over time and implements static and dynamic geofencing to avoid risks. In terms of traffic management, the UTM System plays a role that is both strategic and tactical. At the strategic level, it ensures that airspace is used optimally through segmentation and planning of available airspace. At the tactical level, it observes, tracks, and oversees the airspace, providing warnings to aircraft when required.

There will likely be little direct human intervention in the movement of autonomous flying taxis. One interviewee believed that they would be piloted remotely, but others were sceptical to that, predicting that there eventually would be requirements for complete autonomy. Shrestha et al. (2021) recommends no involvement of humans in monitoring and operations as this would reduce efficiency and introduce erroneous behaviour of pilots.

As interviewees have explained it, before anyone can fly a UAV, a flight plan must be submitted and reviewed. After that, permission to fly in a certain area can be granted. These permitted flying areas are known as air corridors.

> *"The idea is that you submit a kind of route, that 'I want to fly from point A to point B' or 'I am going to fly around a house to conduct an inspection.' Then either you or the system creates a kind of 4D corridor with length, height, width but also with a time dimension, specifying when you are going to fly."*
>
> \- Interviewee 7

Two main types of air corridors have been discussed: static and dynamic ones. Static air corridors are designated spaces in which many UAVs may fly on a regular basis, like a highway in the sky. Dynamic air corridors are unique corridors established for individual flights. Interviewees were generally of the understanding that static corridors would be prevalent. One interviewee brought up the fact that the UK government has planned an approximately 300 km long highway for drones outside London. A system with static corridors like this was believed to better facilitate the establishment of network infrastructure on the ground. Another interviewee suggested that the cost of installing infrastructure in order to support static corridors could be prohibitive in many cases, and that it might only make financial sense to establish them between cities or logistics hubs.

4.2.2 Current Developments

There are multiple companies developing vehicles meant to be used as flying taxis, known as electric Vertical Take-Off and Landing Vehicles (eVTOL). These vehicles are large, electric drones that lift off vertically, and can carry one or more people. Several of the companies involved, such as Lilium, Volocopter and Embraer, are at this stage developing manned eVTOLs, but have expressed ambitions to develop autonomous vehicles later on. Others, such as EHang and Wisk, are exclusively developing autonomous eVTOLs.

Lilium is a German eVTOL developer. As of now, their flagship vehicle is a jet-like manned eVTOL meant to be used for RAM. In the future, CEO Daniel Wiegand envisions that the company will shift to autonomous vehicles, and a range of other uses, including taxi services over shorter distances and sightseeing (Riedel, 2021a). While manned flying taxis may be expensive for passengers to begin with, he believes that with the rise of autonomous technologies and less costly infrastructure, flying taxis will become as affordable as high-speed trains. As flying taxis become autonomous, pilots are instead envisioned to take on monitoring roles, overseeing the flights of many eVTOLs at the same time. The company has partnered with **Ferrovial**, a company specialising in vertiports.

Joby is an American developer of manned eVTOLs. Their primary focus is currently on commuting between cities and suburbs. They are open to the possibility of developing autonomous vehicles in the future, but do not see it as a certainty (Riedel, 2021b). They have entered into a partnership with Uber, in which it has been agreed that Joby will "integrate our aerial ridesharing service into the Uber app, and vice versa, across all U.S. launch markets" (Joby, n.d.).

Volocopter is a German developer of manned eVTOLs, although they are intend to develop autonomous vehicles later on. Apart from just eVTOLs, Volocopter is developing software to be used to order rides, as well as vertiports, thus aiming to create an entire ecosystem related to this service (Volocopter, n.d.).

Wisk is a subsidiary of Boeing that exclusively develops unmanned eVTOLs. In their concept of operations, they give some indication as to how vehicles will be managed, envisioning so-called multi-vehicle supervisors, people whose job it is to monitor flying taxis (Wisk, 2023). While it appears that they will not directly operate as remote pilots, these supervisors could aid in contingency and emergency situations such as selecting the best emergency landing zones, and issuing additional commands. In the same document, they state that their eVTOLs will have behavioural protocols to ensure safe flights in cases when the connection is lost.

KookieJar is a Swedish vertiport company that emphasises the democratisation of air mobility. The company aims to provide vertiports for all AAM use cases.

Skyportz is an Australian vertiport company. Their goal is to establish a sizeable number of vertiports early on, ahead of the coming flying taxi business. They have also launched a wholly owned subsidiary airline, **Wilbur Air**, which aims to provide AAM services with priority access to Skyportz's vertiports (Craig, 2024).

5

Analysis

In the following chapter, the empirical results are discussed and contextualised using the theoretical frameworks. For both connectivity for rural and remote areas as well as autonomous flying taxis, the analysis consists of three main parts. First, value networks based on analysed empirical data are presented, along with discussions around each involved actor and their strategic motives. Second, a business model canvas developed for an identified focal actor in each value network is shown and discussed. Third, potential money flows scenarios between actors are presented.

5.1 Connectivity for Rural and Remote Areas

In the following section, the business modelling for connectivity for rural and remote areas is presented.

5.1.1 Value Network

Empirical findings have led to the development of a value network designed to provide connectivity in rural and remote areas. There are several actors that need to be present in the value network to provide the service. Figure 5.1 shows the main actors and their respective offerings to the network following the model developed by Biem and Caswell (2008). One area of contention during interviews and focus groups was the way in which terrestrial and satellite networks would be connected through a roaming interface. In the value network model presented, there is a new actor called 6G NTN Operator whose role is to enable this connection.

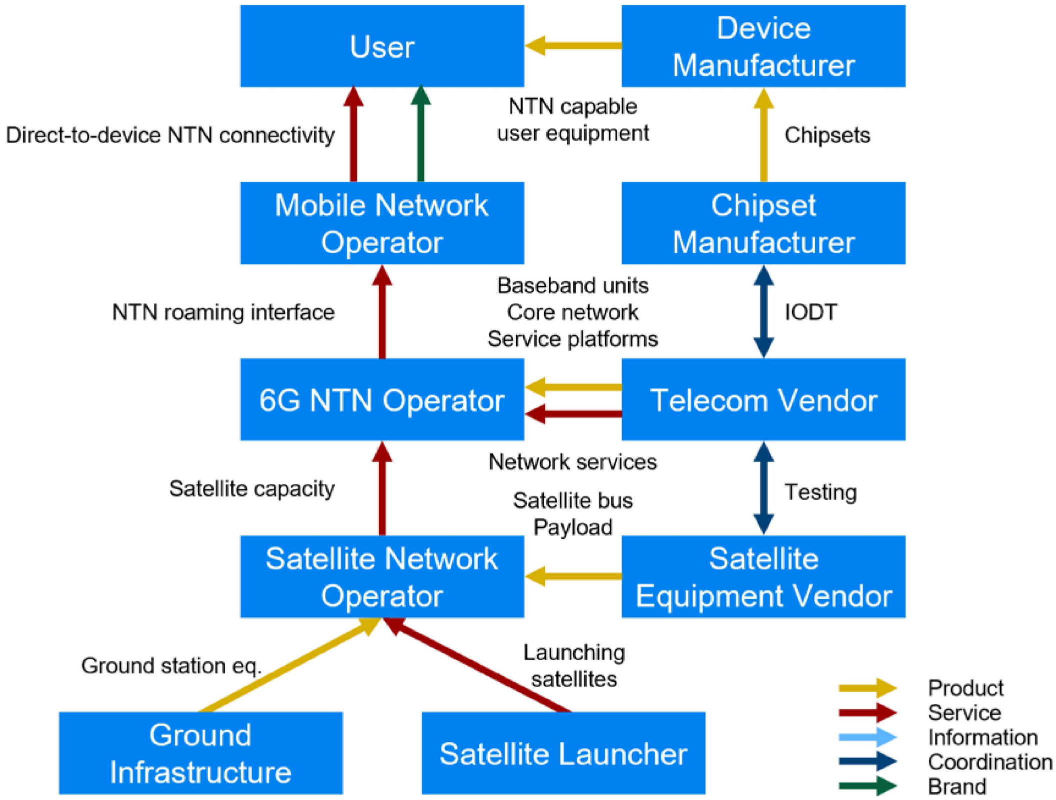

Figure 5.1: Value network for connectivity for rural and remote areas

User

As per Biem and Caswell (2008), the end consumer in a value network is the entity who appreciates the value proposition of the network. In this case, the user is the beneficiary of the value generated by the value network. They are a customer of an MNO, with a phone plan that includes satellite connectivity as an additional service to traditional terrestrial connectivity. When the user exits the area of coverage for their MNO's terrestrial network, their device switches to the satellite network, allowing continued access to services. As previously mentioned, users are unlikely to want additional subscriptions for satellite connectivity; therefore, it is expected that this service will be incorporated into the MNO's existing subscription plans.

Mobile Network Operator

Following the different offerings of network actors from Biem and Caswell (2008), the MNO brings both a service and brand offering. MNOs are the ones selling the rural and remote connectivity service to the user. As interviewees have pointed out, the MNOs already have existing customers, sales channels, and reach on local markets, giving them a strong position in the value network, and an incentive for the rest of the actors to go through them rather than to try to sell the service to end-users directly. Consumers are also likely to only want a single subscription that incorporates both terrestrial and non-terrestrial network access to enable connectivity in rural and remote areas. These factors point to the necessity of the MNO having the customer-facing role in this value network. It is also a possibility that MVNOs, entities utilising MNOs' infrastructure to sell their own services (Balon & Liau, 2012; Shavers & Bair, 2016), can take on this role as well, to differentiate their offering.

MNOs also have rights to terrestrial spectrum (Vuojala et al., 2020), which is necessary for providing a mobile service through terrestrial networks. While the most likely case seems to be that satellite spectrum will be used for satellite connectivity, there are multiple actors attempting to create services using terrestrial spectrum, as is the case with T-Mobile's collaboration with Starlink, so this is certainly a possible scenario.

Satellite Network Operator
Satellite Network Operators own rights to the satellite spectrum. In this model, their role is to provide a wholesaling service of data capacity for NTN connectivity through LEO satellite constellations, allowing users to connect their devices to the satellite to provide the necessary services where terrestrial networks do not reach.

The SNO purchases satellites from a Satellite Equipment Vendor. The satellite consists of a frame, solar cells, and payload. The payload consists of the equipment on the satellite necessary for fulfilling its function.

The architectures used for LEO constellations will depend on the specific use cases. A fully regenerative architecture minimises latency but comes at a higher cost due to additional satellite complexity, despite reduced launch expenses in recent times. Unless essential, SNOs are likely to opt for the cheaper options, especially for a use case like this where only a best-effort type of link is required.

In addition to purchasing satellites, SNOs will also need to buy ground infrastructure and launch their satellites. Ground infrastructure includes satellite gateways, data centres, fibre cables, and more.

6G NTN Operator
Allee (2008) recommends separating specific roles in the value network to analyse how value conversion happens. From the empirical findings, it was evident that a middle-layer between MNOs and traditional SNOs will be required to offer a full TN and NTN service direct-to-device, with discussions centred around which actor would take this role. Traditionally, the simple B2B interface that SNOs have offered

has not required them to provide any additional offerings of their own in the form of services. When it comes to connectivity for rural and remote areas, this means that traditional SNOs currently lack the necessary capabilities to directly integrate with MNOs in roaming agreements. This role thus needs to be taken on by an actor in the value network in order to provide a seamless service to end-users.

While some interviewees believed that the SNO would take on this role in most cases, others believed that actors such as MNOs and Device Manufacturers might have motives to pursue this area. Since this is a rather new role that needs to be taken on by some actor, it has been defined as a separate entity in this model in order to facilitate discussion and analysis, as well as to emphasise its position as a potential future battleground.

The 6G NTN Operator represents this middle-layer between the SNOs and MNOs. The service they provide is a roaming interface from the terrestrial networks of the MNOs to the non-terrestrial networks of the SNOs. This requires a RAN, core network, and service platforms for the voice, messaging, and data services that are provided. The 6G NTN Operator purchases these capabilities from the Telecom Vendor.

The startup Skylo is a real-life example of such a middle-layer role between SNOs and MNOs, albeit for a slightly different use case. Their value proposition entails connecting satellites and MNOs to provide an integrated TN and NTN IoT service. Through building their own RAN at the satellite ground stations, and having their own core network, they have become able to provide the service for IoT devices. A similar role could be envisioned for the case of direct-to-device TN and NTN integration for rural and remote connectivity.

An example of a company that is taking on this role as well as that of the SNO is Starlink, which aims to offer a messaging solution through their constellation of satellites direct-to-device. While they are not making use of satellite spectrum, they provide satellites and develop the network infrastructure that integrates into the terrestrial network.

Telecom Vendor

The Telecom Vendor will be responsible for providing the 6G NTN Operator with RAN and a core network. Mainly, the Telecom Vendor will provide baseband units which will be located on the ground by the satellite gateway, or on the satellites, depending on the payload architecture of the satellite. The Telecom Vendor may also provide additional network services.

In a 6G scenario based on 3GPP, the Telecom Vendor will also play a coordinating role, ensuring compatibility. The coordinating role is a network-centric offering that entails managing the offerings of others (Biem & Caswell, 2008). In this case, they will need to participate in IODT with Chipset Manufacturers. They may also need to conduct testing with Satellite Equipment Vendors to ensure compatibility and performance. Therefore they play a coordinating role in participating in the development of the products of other actors to ensure compatibility.

Chipset Manufacturer and Device Manufacturer
The Chipset Manufacturer will coordinate with the Telecom Vendor to ensure interoperability and compatibility. The Chipset Manufacturer will sell their chips to Device Manufacturers to be used in devices. Standardised chips will ensure that billions of user devices will be compatible with integrated TN and NTN services.

Satellite Equipment Vendor
The Satellite Equipment Vendor builds the physical components of the satellite. This includes the satellite bus, which is essentially the satellite's structural framework, housing various subsystems like power, propulsion, and communication systems. Additionally, they install the antennas on the satellite. They collaborate closely with SNOs to understand their needs and integrate features that enhance the satellite's performance and longevity in orbit.

Satellite Launcher
The Satellite Launcher is responsible for the successful deployment of satellites into their orbits. Launching a satellite involves using specialised rockets or launch vehicles capable of carrying the satellite payload to the desired altitude and trajectory.

Ground Satellite Infrastructure Provider
The ground segment of an SNO encompasses a wide range of infrastructure and facilities on Earth that are essential for satellite communications. This includes gateways that communicate with satellites through feeder links.

5.1.2 Strategic Motives

Actors in the presented value network will have their own strategic motives in trying to shape it to their favour. As Peppard and Rylander (2006) note, actors in emerging value network will act based on perceived value, meaning that each actor will want to grab larger parts of profits. Incumbent actors moving into this market will have certain motives to pursue different positions. In the presented value network, there are five main incumbent actors who have their own agendas in trying to shape the value network. These are the SNOs, MNOs, Device Manufacturers, Chipset Manufacturers, and Telecom Vendors.

Strategic Motives of Satellite Network Operators

As SNOs historically have acted as a "bit pipe" provider for TV channels, they will be eager to find opportunities to expand their offering to generate larger profits. New direct-to-device NTN services are an attractive new opportunity which they likely will want to exploit to fullest extent. As several interviewees highlighted, it is likely that they will want to move to 6G NTN Operator role and build out their own core network to get to the service part of the NTN offering.

One perspective on a firm's competitive advantage is the examination of its internal resources, as suggested by (Barney, 1991). Looking at SNOs, they have two main resources, satellite spectrum and satellite constellations. Spectrum is the main resource that enables a telecommunications business. In the case of SNOs, their access to satellite spectrum puts them in a strong position relative to other actors in the NTN space. The SNOs' resources can be analysed based on the VRIS criteria developed by Barney (1991). Satellite spectrum is valuable since it allows the transmission of data through satellites on certain frequencies. It is also rare, since spectrum is a finite resource with a finite number of owners. Furthermore, it is impossible to imitate. Lastly, it is only to a small degree able to be substituted. As evidenced by Starlink's partnership with T-Mobile, it is possible to use an MNO's terrestrial spectrum on satellites. However, there are interference challenges, and these solutions would only work on certain local markets due to the dependence on an MNO's spectrum. Overall, satellite spectrum is a VRIS resource that puts SNOs in a strong position in the value network for this service.

As presented in the value network, the 6G NTN Operator role requires a RAN and a core network. A frequent topic in interviews was that of the satellite architecture. As discussed by interviewees, there are transparent, semi-transparent, and regenerative architectures for LEO constellations. Interviewees seemed to believe that some type of semi-transparent architecture would be utilised in many cases. This would require parts of the RAN to be integrated on the satellite, including the radio, while other parts would be located on the ground at the ground stations of the SNO. What is evident is that when components become tightly integrated, asset specificity, as described by McGuinness (1991), increases. This type of asset specificity is site specificity (Williamson, 1989), since the radio in this case is contingent upon its physical location. Furthermore, the RAN components on the ground would be located at the ground station of the SNO, which also indicates high asset specificity. When asset specificity is high, firms are more likely to vertically integrate (Riordan & Williamson, 1985). This would point to SNOs being likely to not only provide the satellites and ground stations, but also other parts of the RAN.

In addition to the RAN, the other role of the 6G NTN Operator is to operate a core network and offer the actual service. Since there are digital components, the site specificity of the RAN components is not present. Similar to MVNOs who operate some mobile service through their own services and core network while utilising the RAN of other actors (Balon & Liau, 2012), it would be possible for the SNO to not operate a core network and for another actor to take this role themselves. However, owing to the probable motives of the SNOs to take a larger part of the value network and in effect appropriate larger profits, it is likely that they will have ambitions to operate their own core network as well and provide a service which can simply be integrated with MNOs.

In the scenario provided above, the role of the 6G NTN Operator would be subsumed by the SNO, who then has a direct relationship with the MNO. This scenario is the one that several interviewees envisioned as the most likely. However, building out new infrastructure and capabilities will require large investments from SNOs, which would come in addition to the large investments made in satellite constellations. While the market seems to have potential, it is still uncertain how large the market will become and which services users will be willing to pay for. While most current solutions offer some type of messaging solution, future solutions may incorporate voice calls and data. However, if users do not see much use of these services, the market potential may be significantly smaller than what some might expect. Playing a larger role in the value network will therefore be a risk that SNOs will need to be willing to take.

Concurrently, should the SNOs decide to take a smaller role and maintain their role of a "bit pipe" provider, letting other actors take the role of the 6G NTN Operator, smaller investments would be required from the SNOs. Following the insights from Allee (2008) that each role brings some unique value to the value network, assuming a smaller role would entail that the SNO does not contribute as much value, meaning that they likely will not be able to appropriate as much of the profits.

Another alternative for the SNO would be to go at it alone, and sell a direct-to-device NTN service directly to mobile users. In this case, users would need two contracts for their mobile needs, one with their MNO and one with the SNO, which they would likely find inconvenient. It would also require SNOs to gain a local market presence and access to customer, which they currently do not. They would thus need to deliver a brand offering from the model of Biem and Caswell (2008). This case would also require the SNO to take the role of the 6G NTN Operator. The benefit would be that the SNO could keep profits to themselves, without the use of middle-men which the MNOs would be in the other case. However, the large efforts required to reach users, would likely point to SNOs in most cases wanting to use MNOs as a go-to-market channel for the service.

A third alternative is for SNOs to partner with device manufacturers to provide the service to the users of devices. This would still lead to the problem of users needing two different services for their cellular connectivity needs, but would help SNOs to reach large numbers of devices and users.

Strategic Motives of Mobile Network Operators

MNOs will view NTN services as an opportunity to enhance their service portfolio and meet the evolving needs of their customers, particularly those in rural and remote areas. By offering NTN connectivity, MNOs can position themselves as comprehensive solution providers, catering to underserved populations. This customer-facing role allows MNOs to maintain direct relationships with subscribers, thereby improving customer retention and loyalty.

MNOs possess valuable terrestrial spectrum licenses, which serve as a key competitive advantage in the telecommunications market. This spectrum, acquired through regulatory processes and investments (Vuojala et al., 2020), enables MNOs to deliver wireless services over terrestrial networks. The ownership of terrestrial spectrum can be considered a VRIS resource as defined by Barney (1986) for MNOs. Their access to terrestrial spectrum makes it impossible for other actors to offer a full terrestrial and non-terrestrial service without the cooperation of at least one MNO.

While MNOs lack satellite spectrum and infrastructure, they can leverage existing assets and partnerships to integrate NTN services into their offerings. By collaborating with SNOs, MNOs can access satellite-based connectivity without significant capital expenditures. This allows MNOs to generate additional revenue streams with minimal investment.

With their established market presence and financial resources, MNOs may explore opportunities for vertical integration. This could involve expanding their role beyond traditional service provision to encompass elements of the 6G NTN Operator role such as elements of the core network and a service definition. This would position them as a full MVNO towards the SNOs. The SNOs provide the RAN while the MNO has a core network that utilises the RAN. By assuming greater control over network infrastructure and service delivery, MNOs can capture more value and differentiate themselves in the competitive landscape. Transaction cost economics posits that vertical integration should be done when costs are lower than transacting in the open market (Coase, 1937). From this perspective, it would only be appropriate for the MNO to take a larger role if they are able to reduce transaction costs.

MNOs are likely to advocate for the adoption of industry standards, particularly those established by 3GPP. Standardisation ensures interoperability and compatibility across networks and devices, allowing MNOs to seamlessly integrate NTN connectivity into their existing infrastructure. By supporting 3GPP standards, MNOs can unlock the full potential of NTN services and ensure a smooth transition for their subscribers.

Strategic Motives of Device Manufacturers

For device manufacturers 3GPP NTN standards can enhance the value proposition of their products. By ensuring compatibility with NTN connectivity, manufacturers can offer consumers access to reliable and seamless connectivity, regardless of geographic location.

Some device manufacturers may explore opportunities to provide NTN services directly to consumers by collaborating with SNOs. For example, Apple's partnership with Globalstar to offer emergency SOS services on iPhones exemplifies this approach. By leveraging their brand recognition and resources, device manufacturers can potentially establish additional revenue streams through service provision. However, this strategy may require substantial investments in infrastructure and partnerships, as well as navigating regulatory and technological challenges.

Strategic Motives of Telecom Vendors

As NTN services evolve, Telecom Vendors are likely to push for the standardisation of technical specifications and protocols, particularly through 3GPP. Standardisation promotes interoperability and compatibility between different network components and devices, which puts the Telecom Vendors in a good position to sell their equipment and solutions.

Strategic Motives of Chipset Manufacturers

Chipset Manufacturers' chips will be used to develop NTN capable device, placing them in a good spot to make their chips more valuable and generating more revenue. To gain access to the vast ecosystem of devices, they will be likely to push for 3GPP standardisation. Alternatively, they may favour a proprietary solution if they can secure an agreement that locks out competitors.

5.1.3 Business Model Canvas for 6G NTN Operator

Peppard and Rylander (2006) define the network focal as the entity whose business model relies on the value network. In the value network for connectivity for rural and remote areas, the 6G NTN Operator role was identified as the focal actor in this network, owing to the fact that this role delivers the actual direct-to-device NTN connectivity service. This is done by partnering with traditional SNOs and delivering the service through MNOs to the end-customer.

This section presents a business model canvas based on Osterwalder and Pigneur (2010) for the 6G NTN Operator to further explore this role in the value network. While it is likely that this role may be taken on by companies already fulfilling other roles, the business model canvas has been designed as if the 6G NTN Operators were its own independent actor, to explore all the unique aspects of this role. It is presented in Figure 5.2.

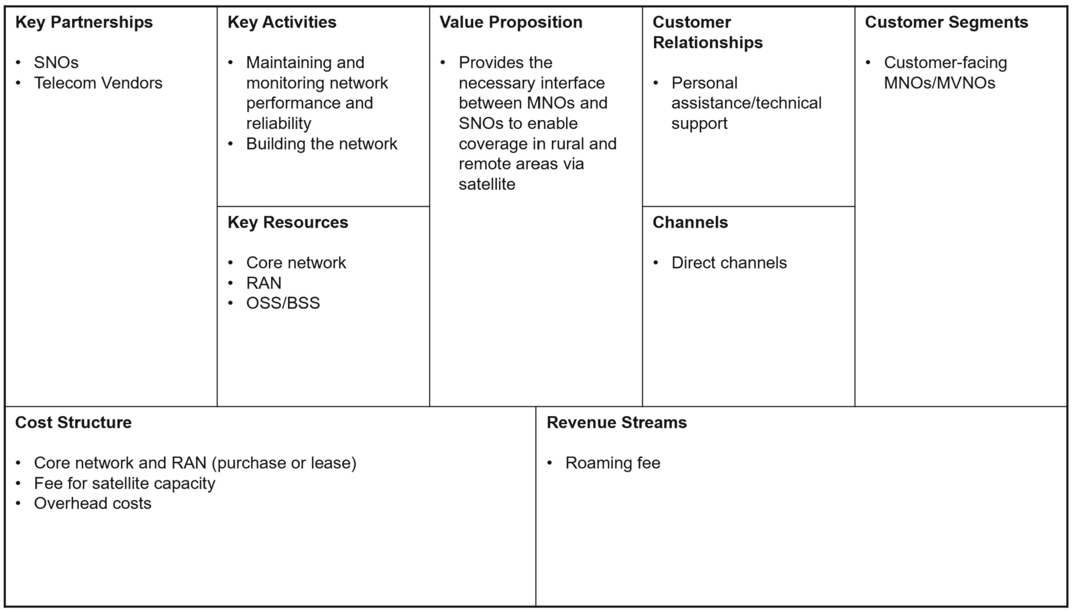

Figure 5.2: Business model canvas for 6G NTN Operator

1. **Customer Segments**
   For this end-consumer-centred use case, there is only one main customer-segment, consisting of customer-facing MNOs and MVNOs. The value proposition itself has been specified to suit this kind of company, and so they are the only ones who can take full advantage of it.

2. **Value Propositions**
   The value that is offered by the 6G NTN Operator is the provision of the necessary interface between an MNO and an SNO to enable customers of the MNO to get coverage through the SNO's network when outside the range of the MNO's network. An important aspect of this offering is that very little is required of the MNO in terms of labour or financial investment. Since it is the 6G NTN Operator and the SNO that provide the actual network, the MNO only needs to negotiate a roaming agreement and then enable its customers to opt in to the service. This means that MNOs stand to increase their revenue at virtually no risk.

3. **Channels**
   As this kind of agreement is likely to be between relatively large companies, negotiations and sales will probably be done through direct channels as defined by Osterwalder and Pigneur (2010). The 6G NTN Operator may contact MNOs directly to attempt to sell their service, or MNOs may contact them if their reputation is strong enough.

4. **Customer Relationships**
   While aspects such as billing may be automated, the customer relationship type from Osterwalder and Pigneur (2010) that the 6G NTN Operator will provide will likely be some form of dedicated personal assistance where they will find the best solution for each customer.

5. **Revenue Streams**
   The main revenue stream for the 6G NTN Operator will come from MNOs whose customers are roaming on their networks. The money received for providing this service will likely be a usage fee as defined by Osterwalder and Pigneur (2010), based on the amount of voice calls, text messages and mobile data used, as is normally the case with terrestrial roaming (Spruytte et al., 2017).They may also charge some form of recurring subscription fee for access to the service (Osterwalder & Pigneur, 2010).

6. **Key Resources**
   Of the resources defined by Osterwalder and Pigneur (2010), the main resources the 6G NTN Operator will have are physical ones. This includes network infrastructure that the 6G NTN Operator owns, consisting of the core network, RAN and BSS, which are necessary to provide this service.

7. **Key Activities**
   The key activities are maintaining and monitoring the network to ensure performance and reliability. The network is the main offering that the actor has, so ensuring that it works as well as possible is of the utmost importance. This will involve monitoring values from the core network, inspecting hardware placed at gateways, and cooperating with the SNO to ensure that the satellites are working as they should.

8. **Key Partnerships**
   There are several actors that the 6G NTN Operator must enter into partnerships with to provide this service. Osterwalder and Pigneur (2010) highlight partnerships as a means to access resources and activities of others. This is the main purpose of partnerships for the 6G NTN Operator.

The SNO is a crucial collaborator, as this actor provides the network of satellites that the NTN will make use of. There will have to be close cooperation here, as it must be ensured that the satellites are able to facilitate the connectivity. This is especially true if a regenerative architecture is to be used, as that involves network infrastructure being placed on satellites.

While some network infrastructure could be developed in-house, it is very likely that most if not all of it is purchased from a Telecom Vendor. This may involve some cooperation, as the offering will be somewhat customised for the 6G NTN Operator's needs.

9. **Cost Structure**
   As mentioned, network infrastructure such as the core network and RAN is likely to be purchased from a Telecom Vendor, and this may be in the form of an outright purchase or some kind of leasing agreement where the core network and RAN are provided as a service.

   The 6G NTN Operator pays a wholesale price for the satellite capacity that it uses. Furthermore, there are overhead costs, consisting of salaries for employees, and rent for office space, ground infrastructure etc.

5.1.4 Money Flows

This section looks into the value network in terms of probable money flows. The money flows are presented in Figure 5.3.

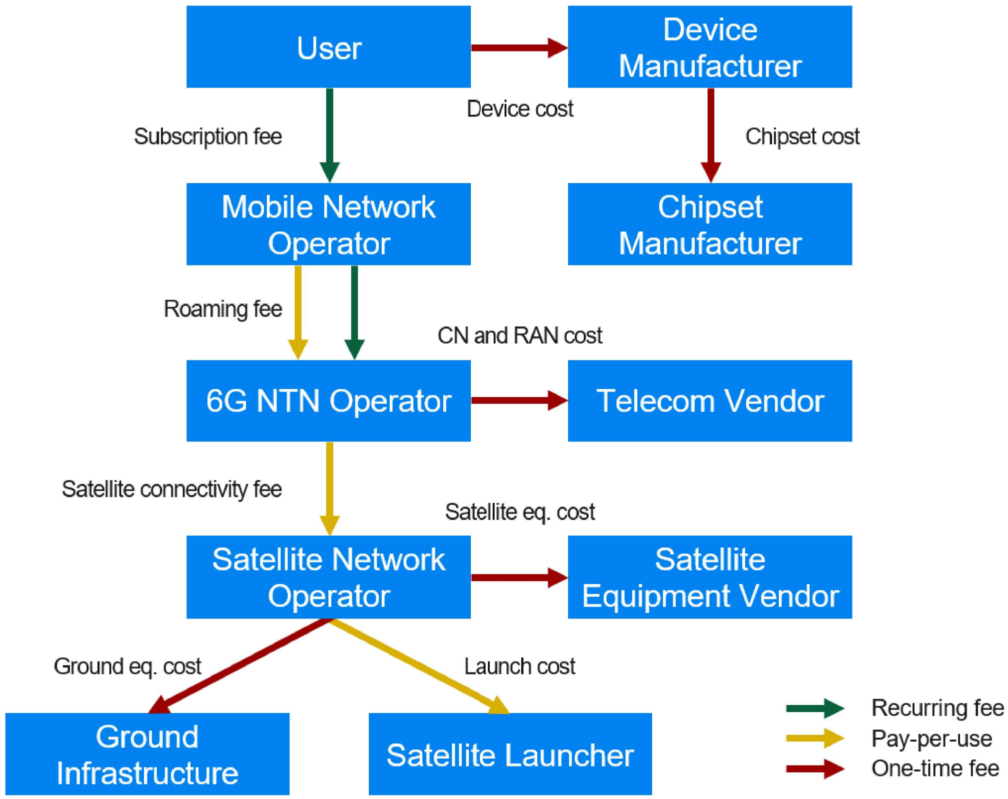

Figure 5.3: Money flows for connectivity for rural and remote areas

User

The user is the origin of the monetary flow in the value network, purchasing NTN-capable devices directly from the device manufacturer. While mobile phones are often sold by MNOs and other third-party retailers, this model in Figure 5.3 simplifies the financial flow from the user to the device manufacturer.

Enders et al. (2019) note that customers generally expect features integrated with core offerings to be integrated in the same revenue stream. It is therefore likely that users will want to pay for NTN services through their existing MNO subscription. MNOs can charge for this by setting higher subscription rates and assigning a specific data allowance for NTN usage. The MNO may offer various NTN plans, ranging from messaging-only to comprehensive packages that include messaging, voice, and data. This type of pricing is called tiered pricing, and is beneficial to reach customers who value the aspects of the product differently (Mohammed, 2005).

As customers often expect certain revenue models to be available due to them being common practice (Enders et al., 2019), other solutions that are prevalent in the telecommunications industry may of course be possible. These may include pre-paid SIM cards or usage-based fees, akin to roaming charges, as described by Spruytte et al. (2017).

Mobile Network Operator

Typically, the operator of a visited network charges a wholesale fee for used capacity (Spruytte et al., 2017). Therefore, in the proposed model, the MNO will be required to pay a roaming fee based on usage to the 6G NTN Operator to allow user access to the network. This flexibility would make it easy for the MNO to add new subscribers to the service and only pay for the service when their customers use it. The MNO's payments for NTN connectivity will therefore be based on the data consumption of each user.

6G NTN Operator

The 6G NTN Operator accesses satellite capacity from SNOs. In this arrangement, the SNO functions similarly to a traditional wholesaler of capacity. Consequently, the 6G NTN Operator compensates the SNO based on the pay-per-use model for the utilised capacity. Furthermore, they procure network equipment and services from the Telecom Vendor. Equipment is likely paid for up-front, as that is a common revenue model for goods (Iveroth et al., 2013). Occasional services provided will likely be billed on a per-use basis (Ojala, 2013).

An alternative solution would be for the Telecom Vendor to offer a comprehensive service package, enabling the 6G NTN Operator to purchase a core network, RAN equipment, and services like OSS/BSS as a network-as-a-service proposition, with recurring charges. This model could be appropriate for a fledgling 6G NTN Operator, as it would lower capital expenditures and minimise financial risk (Ojala, 2013). Furthermore, improvements to the product could be made over time, making it more valuable for the customer (Iveroth et al., 2013).

Satellite Network Operator

The three main costs of SNOs are the cost of satellites, launch, and ground infrastructure. Satellites and ground infrastructure are durable products that will be used a lot, pointing to likely up-front payment model (Sato & Nakashima, 2020). Satellite launches are infrequent and have a very specific purpose, indicating that a usage-based model is likely in this case (Ojala, 2013).

Device Manufacturer

In this value network, the main purchase for the device manufacturer are chipsets. Given the nature of chipsets as standardised and essential components, the purchasing of these will likely be in the form of one-time payments, as that is the standard revenue model for goods (Iveroth et al., 2013).

5.2 Autonomous Flying Taxis

The following section presents the business modelling for connectivity for autonomous flying taxis, grounded in empirical findings. Initially, a value network is established, succeeded by the creation of a business model canvas for a focal actor, and concluding with the development of a money flow scenario.

5.2.1 Value Network

The following section presents the value network for providing the necessary connectivity for autonomous flying taxis. Similar to the previous case, a value network will be presented based on the model of Biem and Caswell (2008) and is shown in Figure 5.4.

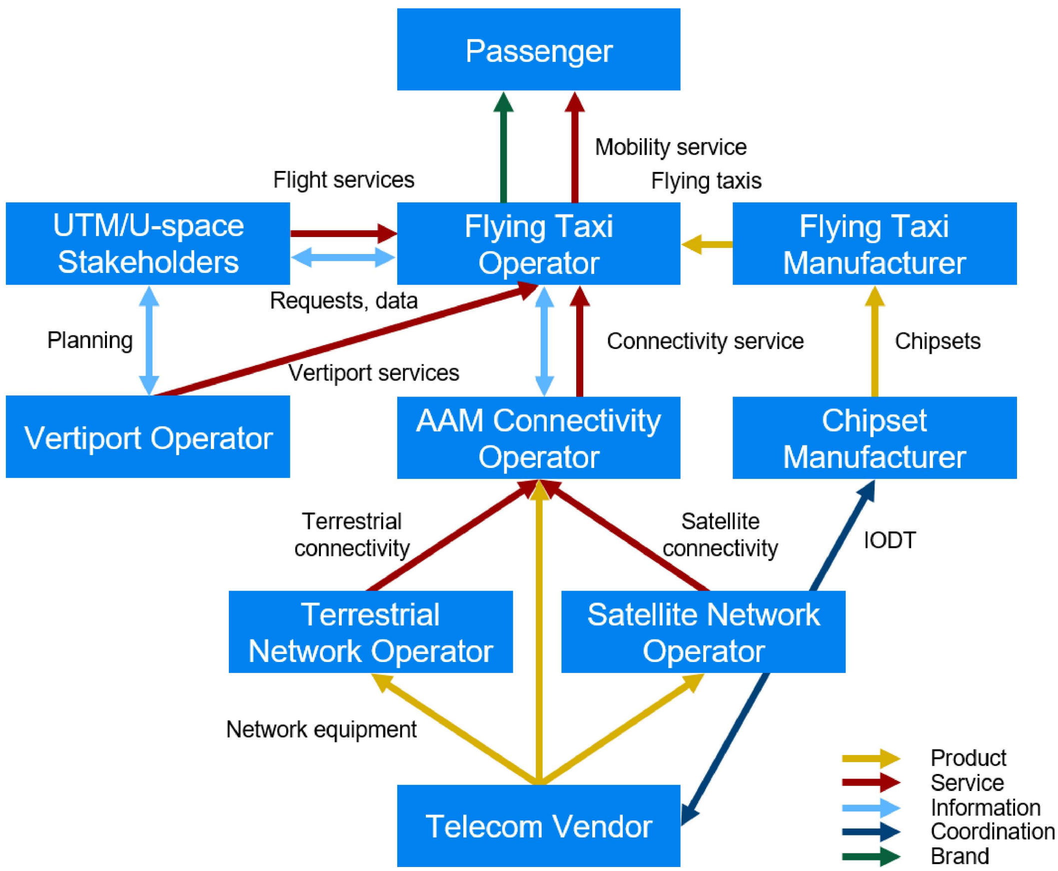

Figure 5.4: Value network for connectivity for autonomous flying taxis

Passenger

The passenger is the end-customer, receiving the service of mobility in the air. The Passenger interacts with the Flying Taxi Operator's app or website to book a flight.

They then make their way to a pre-determined vertiport and board a flying taxi that transports them to another vertiport somewhere else. This could be within a city, from one city to another, or between a city and a specific location outside the city, such as an airport (Hader et al., 2020).

Flying Taxi Operator

The Flying Taxi Operator operates a mobility service that interviewees believe will function similarly to modern taxi apps such as Uber, Lyft and Bolt. That means that it owns and operates a customer-facing interface, presumably a website and an app, through which customers can book eVTOL flights. This is categorised as a service, as per Biem and Caswell (2008).

Unlike the aforementioned taxi services, whose drivers operate their own cars, the Flying Taxi Operator will be required to either own or lease its own eVTOLs. This will likely be done directly from the manufacturer, but an intermediary could also be involved. Reliable, uninterrupted connectivity for the flying taxis over both terrestrial and non-terrestrial networks is purchased from the AAM Connectivity Operator. Access to vertiports is purchased from Vertiport Operators.

Based on Biem and Caswell (2008), the Flying Taxi Operator provides a service, information, as well as a brand offering to the value network. In addition to the mobility service, their brand offering involves marketing the solution to customers and competing against other firms. Furthermore, there must be continuous interaction with the UTM/U-Space Stakeholders, as approval for flights must be requested, real-time data must be sent communicating location, flight paths and other values, and information on aspects such as traffic and weather must be received (Shrestha et al., 2021). They also communicate flight plans and real-time data with the AAM Connectivity Operator in order to enable seamless handover.

UTM/U-Space Stakeholders

The exact configuration of the traffic management system for flying taxis is uncertain and this position therefore includes all the entities involved in UAV air traffic management in a given country, known as UTM in the US and U-Space in the EU. While the actors involved in this network may vary, they typically include a mix of governmental authorities and private companies. In this use case, their main role is to oversee the airspace to ensure safety for everyone. This is done through communicating with Flying Taxi Operators and Vertiport Operators. Collectively, the UTM/U-Space Stakeholders receive and approve flight plans, send information on traffic and weather, and use the real-time data received to coordinate and oversee all air traffic (Shrestha et al., 2021). From the offerings of Biem and Caswell (2008), they mainly provide service and informational offerings to the value network.

AAM Connectivity Operator

The AAM Connectivity Operator fills the need for coordination between Terrestrial Network Operators that has been identified by interviewees. It provides reliable, uninterrupted connectivity to the Flying Taxi Operator and other AAM service providers. This is a service offering as per the framework outlined by Biem and Caswell (2008). Its role could be likened to that of an MVNO that aggregates the networks of different operators, both terrestrial and satellite-based, and provides a service for a select number of corporate customers (Balon & Liau, 2012).

As interviewees have pointed out, TNs are unlikely to have sufficient coverage for a flying taxi connectivity service on their own, so satellite networks must be used for areas outside of their reach, as well as for redundancy. It may be necessary for the AAM Connectivity Operator to secure agreements with several different Terrestrial Network Operators to gain access to their network infrastructures. This aggregator role allows Flying Taxi Operators to make an agreement with just one vendor for all of their connectivity needs. Using transaction costs as a basis for analysis per Riordan and Williamson (1985), the Flying Taxi Operator reduces their number of contracts and thus transaction costs, much like with a roaming broker (Salsas & Koboldt, 2004).

This service would involve the flying taxis roaming between these networks, always receiving the best connection available at any given location. This is similar to the role of MVNOs that provide SIM cards for IoT devices mentioned by interviewees, as well as the Air-to-Ground Operator for in-flight broadband communication on commercial airplanes described by Dinc et al. (2017), although flying taxis will predominantly be operating within national borders. As interviewees have noted, if several Terrestrial Network Operators are to be used, regulations on national roaming may need to be updated before this can happen in some countries.

To enable smooth handovers for flying taxis, interviewees believed that the AAM Connectivity Operator would be likely to need a core network of its own, as the Air-to-Ground Operator does in one of the scenarios described by Dinc et al. (2017). This will be purchased from a Telecom Vendor. Interviewees agreed that to enable seamless handover, a continuous exchange of information between the Flying Taxi Operator and the AAM Connectivity Operator may be necessary, where flight plans and real-time data are gathered so connections can be planned out and communicated prior to flights taking place. This is classified as a two-way information offering as per Biem and Caswell (2008).

Terrestrial Network Operator

Terrestrial Network Operators are likely to be the same companies that are referred to as Mobile Network Operators in the previous use case, but here they have been given a different name to emphasise that their main contribution to the value network is their terrestrial network infrastructure, and that mobile phones are not served. These operators let customers of the AAM Connectivity Operator connect to their base stations, providing terrestrial coverage. They provide a service offering based on Biem and Caswell (2008).

To support UAV connectivity, Terrestrial Network Operators must either adjust their existing network equipment by tilting antennas upwards, or install new equipment (Bae et al., 2022). As interviewees pointed out, network equipment is typically purchased from a Telecom Vendor, and networks may only on occasion be supplemented by HAPS.

Satellite Network Operator
The main role of the SNO in the value network of autonomous flying taxis is to provide satellite-based network coverage in areas that terrestrial networks do not reach, as well as to provide an additional network for redundancy. This is a service offering, as per Biem and Caswell (2008). This is a necessary role, as interviewees agree that UAVs are likely to fly in areas where terrestrial networks will be unable to provide coverage due to prohibitive costs.

Although there are other possible scenarios, it is assumed for simplicity that the SNO in this case also takes on the role of the 6G NTN Operator as presented in the case for connectivity for rural and remote areas. This thus means that the SNO has the required capabilities to provide a roaming interface to the AAM Connectivity Operator. The Satellite Launcher, Ground Infrastructure Provider and Satellite Equipment Vendor, while still present, have also been removed from this model to avoid clutter.

Telecom Vendor
The Telecom Vendor plays a similar role here as in the previous use case. It provides network infrastructure and equipment to Terrestrial Operators and Satellite Network Operators. It is likely that it will sell its products, including a core network, to the AAM Connectivity Operator as well. These offerings are categorised as products as per Biem and Caswell (2008).

Additionally, as interviewees have suggested, the Telecom Vendor conducts IODT with the Chipset Manufacturer to ensure that the chipsets that eventually get installed in the flying taxis will be able to connect to the network adequately. This exchange is categorised as coordination as per Biem and Caswell (2008).

Chipset Manufacturer

The Chipset Manufacturer coordinates with the Telecom Vendor to develop chipsets that enable the flying taxis to connect to the networks. As interviewees have pointed out, these chipsets are unlikely to be sold directly to the Flying Taxi Manufacturer, rather there will be actors in between that incorporate these chipsets into modules and components that in turn get installed in the vehicles. However, these intermediary actors have been omitted from the model for simplicity. As per Biem and Caswell (2008), this can then be considered a product offering to the Flying Taxi Manufacturer.

Flying Taxi Manufacturer
The Flying Taxi Manufacturer develops and creates flying taxis. The vehicles are then made available to the Flying Taxi Operator, to be used for the mobility service. This is categorised as a product offering as per Biem and Caswell (2008), although additional services or more involved partnerships are also possible, as has been seen from the intentions of current actors.

To enable connectivity, it is likely that components containing chipsets from the Chipset Manufacturer will be purchased, as interviewees have pointed out. Any other potential suppliers have been omitted.

Vertiport Operator
Vertiport Operators provide platforms for take-off and landing. Flying taxis will also be able to get their batteries charged here (Rajendran & Pagel, 2020). This is categorised as a service, as per Biem and Caswell (2008). As interviewees have mentioned, it is possible that network infrastructure for AAM is installed here.

To aid the scheduling of flights, the Vertiport Operator needs to provide data on availability to the UTM/U-Space Stakeholders. This is categorised as an information offering, as per Biem and Caswell (2008).

5.2.2 Strategic Motives

The value network for connectivity for autonomous flying taxis is in its early stages, and can be called an opportunity network as defined by Peppard and Rylander (2006). Different emerging actors in the value network may have their own agendas in trying to shape the value network. This section looks into potential motivations behind different actors. Only motivations of actors involved in the provisioning or purchasing of connectivity will be considered, as other actors are considered secondary to the development of the value network.

Strategic Motives of Flying Taxi Operators
It is likely that the Flying Taxi Operator would seek out one single service that

covers all of its connectivity needs, as a preference and out of necessity. Taking a transaction cost perspective (Riordan & Williamson, 1985), it makes sense for this actor to want to minimise the amount of other actors with which it makes agreements. The prevalence of roaming brokers in the telecom industry (Liaqat & Køien, 2023) indicates that this is a common mindset.

However, this may even be a prerequisite, as interviewees have suggested that only an actor like the AAM Connectivity Operator, who aggregates multiple networks and integrates them using its own core network, could provide sufficiently continuous connectivity and seamless handovers. While it may potentially be possible for the Flying Taxi Operator to develop these capabilities itself, such an upstream vertical integration would once again require a larger number of contracts, thus increasing the transaction costs (Coase, 1937), and so does not make sense.

Strategic Motives of AAM Connectivity Operators

Taking a resource-based view (Barney, 1991), the AAM Connectivity Operator's main source of competitive advantage would be its network of partnering Terrestrial Network Operators and SNOs whose RAN it uses for its service, as well as its accumulated know-how relating to making and managing these agreements. Another important resource would be its core network, which helps to ensure continuous connectivity, and along with this, its experience in providing this service and complying with systems like UTM and U-Space. Competitors could quite easily purchase a core network from a Telecom Vendor, but the network of partners and expertise would be harder to imitate.

It would make sense for the AAM Connectivity Operator to base its strategy on exploiting these resources and capabilities (Wernerfelt, 1984). One obvious way to do that would be to expand and provide its services internationally. The accumulated know-how related to managing the network and negotiating with other actors would certainly be transferable between many different countries, especially those that use a common air traffic management system, such as U-Space. However, if the service were to be provided directly by a Terrestrial Network Operator using its own network, this may not be as likely, as the resources would be less transferable to other geographies.

The geographical scope of operations for AAM Connectivity Operators will be limited by the availability of TN infrastructure, meaning that they will be dependent on the resources of Terrestrial Network Operators. As resource dependency is one of the main reasons to enter into inter-firm relationships (Basole, 2008), this could be an incentive to invest in installing more network infrastructure as a joint venture with Terrestrial Network Operators.

Strategic Motives of Terrestrial Network Operators

As mentioned, Terrestrial Network Operators are likely to be the same companies that are referred to as MNOs in the previous use case. That means that their main resources are their network infrastructure, which includes RAN and a core network, and their spectrum rights. These resources are valuable, though not rare or inimitable among direct competitors, and they are to a limited extent able to be substituted for satellites. They can thus not be considered VRIS resources, as per Barney (1991).

The necessity for Terrestrial Network Operators to modify their existing infrastructure or invest in new equipment to support UAV connectivity underscores the concept of asset specificity, as described by McGuinness (1991). Specifically, it highlights how the unique requirements of connectivity for flying taxis create a need for specialised assets tailored to this application. This asset specificity can increase the costs and risks associated with investment decisions. This suggests that there might be an incentive for Terrestrial Network Operators who pursue these investments to vertically integrate downstream.

It has been strongly suggested by interviewees that an AAM connectivity service would require the resources of several Terrestrial Network Operators as well as SNOs to be successful. For one Terrestrial Network Operator to step up and try to take on this aggregating role, its competitors would be required not only to acquiesce to this but actively cooperate, which they may be reluctant to do. Resource dependence is one of the main reasons for companies to enter into inter-firm relationships (Basole, 2008). Considering this, an AAM Connectivity Operator could instead be created as a joint venture by several Terrestrial Network Operators, if it is not an independent third party.

Alternatively, a Terrestrial Network Operator may ignore the need for other operators, and start out by providing a more limited service, only offering connectivity in specific areas where it can reliably provide coverage using its own infrastructure. Following this, it could gradually increase its area of coverage. If static air corridors are established or other areas where the demand for AAM is high are identified, installing RAN here would certainly make sense. From a resource-based view (Barney, 1991), this increasing base of RAN that supports AAM, along with the increasing list of established customers, would constitute valuable and rare resources if done before competitors.

On the other hand, Terrestrial Network Operators would have to develop the appropriate skills for planning out connectivity and preparing for seamless handovers to provide this service. New relationships with Flying Taxi Operators would also need to be established. This would require time and resources to do, as well as incur increased transaction costs, which may dissuade potential Terrestrial Network Operators from pursuing this role (Coase, 1937).

Strategic Motives of Satellite Network Operators

SNOs' main resources are their fleets of satellites, and their associated networks, which are able to support AAM. From a resource-based view, it would make sense for SNOs to base their strategy on exploiting these resources as much as possible (Wernerfelt, 1984). One obvious way to do this would be to offer services internationally. Assuming a high level of standardisation across the world when it comes to the connectivity of flying taxis, this would be very easily achievable, as any satellites deployed could immediately be used in many different countries. This could indicate that there is an incentive for SNOs to support the development of the AAM industry around the world, as that would allow them to better take advantage of their assets. Due to this international scope, it is unlikely that SNOs would be willing to take on any additional roles in specific countries.

Strategic Motives of Telecom Vendors

Telecom Vendors' main resources are their know-how and expertise in developing telecommunication equipment. It would make sense for Telecom Vendors to want to exploit these resources as much as possible (Wernerfelt, 1984). As with the previous use case, this means that they are likely to push for standardisation in the wireless technology of the flying taxis to promote compatibility with their products at the lowest cost.

5.2.3 Business Model Canvas for AAM Connectivity Operator

Following a similar line of reasoning as in the previous use case, and the definition of the network focal from Peppard and Rylander (2006), the AAM Connectivity Operator was identified as the focal actor of this use case since they will be the central entity bringing the different actors together to deliver the value proposition to the end-user. This section shows the business model through the business model canvas of Osterwalder and Pigneur (2010) for the AAM Connectivity Operator in order to gain further insight into what this role will entail.

<table>
<tr>
<td rowspan="2">Key Partnerships
• TN operators
• SNOs
• Telecom vendor</td>
<td>Key Activities
• Dealing with partners to ensure network performance and reliability
• Enabling seamless handover
• Dealing w/regulators</td>
<td rowspan="2">Value Proposition
• Keep all flying taxis always connected per specific requirements
• Custom solutions based on customers' needs</td>
<td>Customer Relationships
• Personal assistance</td>
<td rowspan="2">Customer Segments
• Flying taxi operators (inter-city, intra-city, airport shuttle)
• (Other autonomous drone operators)</td>
</tr>
<tr>
<td>Key Resources
• Network access
• Intellectual resources</td>
<td>Channels
• Direct channels</td>
</tr>
<tr>
<td colspan="2">Cost Structure
• Cost for access to terrestrial and satellite networks based on SLA
• Core network
• Overhead costs</td>
<td colspan="3">Revenue Streams
• Usage fee (amount of data, time connected, number of flights, or distance travelled)</td>
</tr>
</table>

Figure 5.5: Business model canvas for AAM Connectivity Operator

1. **Customer Segments**
   The AAM Connectivity Operator will serve different customer segments within advanced air mobility. For autonomous flying taxis, they will provide connectivity services for intra-city, airport shuttle, and inter-city mobility. Using the categories identified by Osterwalder and Pigneur (2010), the customers served can be considered a *niche market*, as AAM actors will have quite specific needs that differ from typical consumer offerings. However, they could also come to be categorised as *segmented*, depending on how much the needs of various kinds of AAM actors differ.

2. **Value Propositions**
   The AAM Connectivity Operator's value proposition is to provide the Flying Taxi Operator with reliable connectivity that meets the strict requirements that are likely to be set for autonomous flying taxis, ensuring safe operations in the areas where they intend to operate. Preliminary requirements for connectivity for autonomous flying taxis have been outlined above, and the main value that AAM Connectivity Operator will bring is to meet these requirements. Using the categories identified by Osterwalder and Pigneur (2010), this value proposition can be considered to be *"getting the job done"*, as it fills a need that Flying Taxi Operators have at the required level. There may also be an aspect of *customisation*, as different AAM actors may need unique solutions, perhaps only requiring coverage in certain areas. Additionally, while meeting the requirements is the most important aspect, it is possible that

AAM Connectivity Operators may come to compete based on *performance*.

3. **Channels**
Owing to the relatively large and few customers, it is likely that AAM Connectivity Operators will communicate directly with customers on local markets. This would be categorised as a *direct sales force*, as per Osterwalder and Pigneur (2010).

4. **Customer Relationships**
As discussed, AAM Connectivity Operator will need close collaboration with its customers, Flying Taxi Operators. In the beginning, there must be personal communication and cooperation to plan out how the service will work. Going by the categories identified by Osterwalder and Pigneur (2010), establishing and maintaining this kind of relationship will most likely require *personal assistance*, or even *dedicated personal assistance*. However, as certain operational functions may be automated, such as with the continuous communication of flight plans that allows AAM Connectivity Operators to better plan out capacity in their networks and prepare seamless handovers, there may also be an element of *automated services*.

5. **Revenue Streams**
AAM Connectivity Operator will sell a connectivity service to Flying Taxi Operators. There are several possibilities for how to charge customers for the service. Some possibilities include charging customers based on amount of data used, total time vehicles have been connected, per-flight, or total distance travelled. These can all be categorised as *volume dependent usage fees*, as per Osterwalder and Pigneur (2010). They are discussed in more detail in the next section.

6. **Key Resources**
As mentioned in the previous section, the AAM Connectivity Operator's main resources are its network of partnering Terrestrial Network Operators, its know-how related to making agreements and providing the connectivity service, as well as the core network and other related systems that it owns. Using the categories identified by Osterwalder and Pigneur (2010), the first two can be considered *intellectual resources*, while the last one is a *physical resource*.

7. **Key Activities**
The main key activities are dealing with partnering Terrestrial Network Operators and SNOs to ensure that network performance and availability meet the requirements, and planning connectivity to ensure that handovers are seamless. Furthermore, dealing with regulators in local markets could also

become a key activity for the AAM Connectivity Operator. Going by the categories identified by Osterwalder and Pigneur (2010), these can be considered *platform/network* activities, as the AAM Connectivity Operator is essentially providing an advanced platform for connecting network providers with AAM actors. Another key activity is communicating with customers and making sales, which involves defining what the customers' needs are and finding a solution for them, and thus has an element of *problem solving*.

8. **Key Partnerships**
   The strict requirements for connectivity as well as the fact that AAM Connectivity Operators are unlikely to own their own network infrastructure makes close partnerships with Terrestrial Network Operators and SNOs very important. To guarantee adequate networks performance, certain agreements will need to be put in place to ensure accountability between the different parties. Using the categories identified by Osterwalder and Pigneur (2010), this kind of partnership can be considered an *acquisition of particular resources and activities*, since it is mainly for their resources that these partnerships are entered into. Additionally, AAM Connectivity Operators will have partnerships with the Telecom Vendors from which they buy their network equipment. This is instead a partnership motivated by a desire for *optimisation and economy of scale*.

9. **Cost Structure**
   The main expenses for AAM Connectivity Operators will be paying for access to terrestrial and satellite networks, purchasing the core network, and overhead costs related to salaries and rents. The first two can be categorised as *variable costs*, and the third as a *fixed cost*, as per Osterwalder and Pigneur (2010). The nature of the payment to providers is explored further in the next section.

5.2.4 Money Flows

In the following section, money flows are discussed. In the figure below, one likely scenario is presented. After that, each exchange is explained further, with some potential alternate scenarios also discussed.

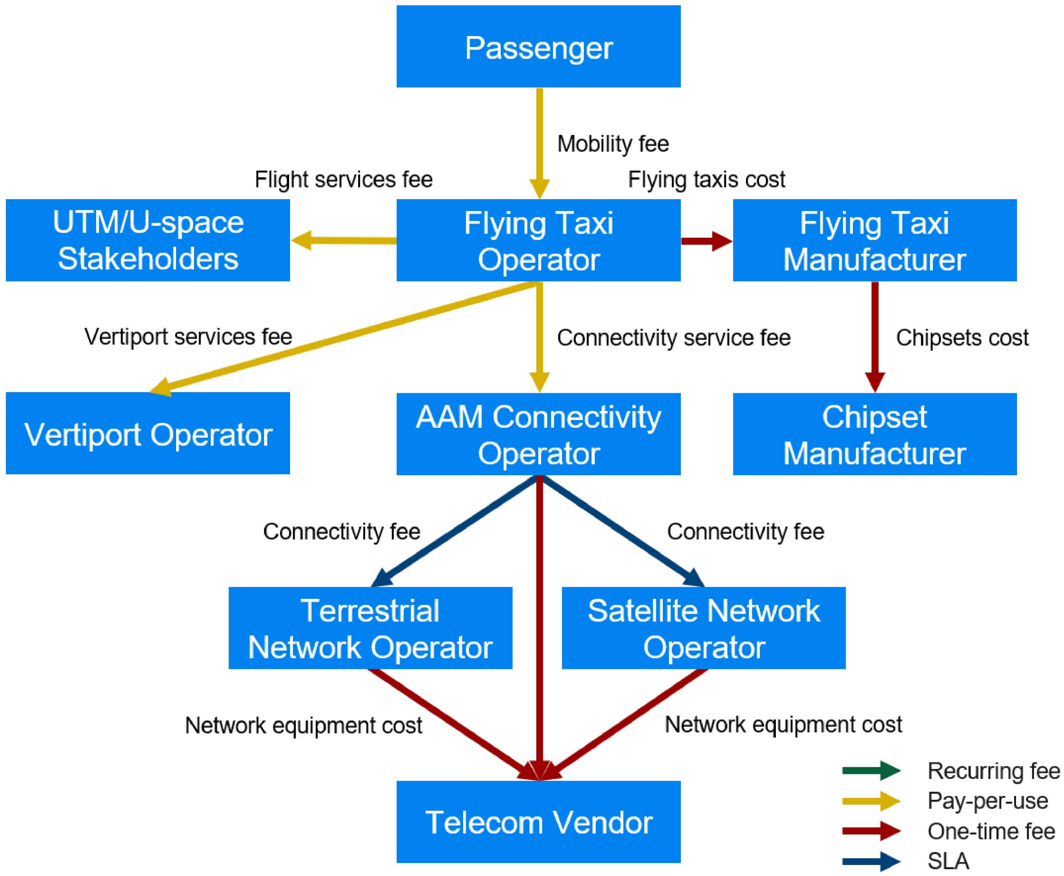

Figure 5.6: Money flows for connectivity for autonomous flying taxis

Passenger

The money flow starts from the Passenger, who pays a fee to the Flying Taxi Operator for each flight. Typically, when a user only occasionally uses a service, it is more attractive for the customer to only pay when they use the service (Ojala, 2013). The pricing could be calculated based on factors such as the distance flown, time of day, traffic, current demand, and other factors. If a passenger uses the service frequently, they may prefer a subscription-based option for convenience and potential cost savings.

Flying Taxi Operator

The Flying Taxi Operator purchases eVTOLs from the Flying Taxi Manufacturer. This is likely to be in the form of a one-time-fee model, since they are durable products and used frequently (Sato & Nakashima, 2020).

An alternative to this model would be a recurring cost for leasing the eVTOLs. That would reduce the capital expenditure required of a Flying Taxi Operator (Enders et al., 2019), and allow them more freedom to modify the size of their fleet. In a situation where the Flying Taxi Manufacturer takes on some of the responsibilities of operating the service, this could be a more likely scenario.

Vertiport Operators are likely to get paid whenever flying taxis land on their platforms, perhaps with additional fees based on what other provided services, such as charging. Since the use of vertiports will be based on how often passengers choose to fly to them, it is likely to be sporadic and irregular. This suggests that Flying Taxi Operators would prefer their revenue model to employ a pay-per-use model (Ojala, 2013). However, the fact that Vertiport Operators must make their vertiports available and maintain them regardless of whether UAVs land on them or not, which thus constitutes a continuous expense, could suggest that they might prefer a subscription model (Enders et al., 2019).

In order to be allowed to operate, Flying Taxi Operators will have to pay the UTM/U-Space Stakeholders for their services. While there may be one-time or recurring certification fees, it is likely that this will mainly be charged for based on the distance flown, as suggested by one interviewee, who referred to the fact that traditional air traffic management uses this revenue model. This model is thus common practice for this type of service, making it likely that customers would expect this form of payment, as per Enders et al. (2019).

The Flying Taxi Operator must pay the AAM Connectivity Operator in order for its eVTOLs to keep them connected for the duration of each flight. The Flying Taxi Operator is unlikely to possess advanced knowledge on connectivity, and this is a relatively sophisticated service with some customisation involved, so employing a usage-based model would be in line with Tabares et al. (2023). Metrics used to determine the amount paid could include the distance travelled or amount of data. This revenue model could also serve to make the service more accessible to a broader range of AAM actors (Ojala, 2013).

Flying Taxi Manufacturer

The Flying Taxi Manufacturer purchases modules or gateways that contain chipsets that enable connectivity for the flying taxis. These are likely to be purchased outright, with an up-front payment, as that is the traditional model used for goods such as these (Iveroth et al., 2013).

AAM Connectivity Operator

The AAM Connectivity Operator pays Terrestrial Network Operators and SNOs for access to their networks. Due to the the strict connectivity requirements and the fact that they do not own much of the network infrastructure that enables their service, the AAM Connectivity Operator is likely to want a guaranteed high level of service from its providers. Interviewees suggested that SLAs with KPI-based penalties would be suitable for this. Using a performance-based model such as this would be in line with Tabares et al. (2023), who note that this revenue model is ideal for customers who wish to share risk with its providers, as well as for services that involve a high degree of collaboration among actors within a value network. In practice, an SLA would be similar to a pay-per-use model based on data usage, but with KPI-based payment deductions in the case that connectivity performance does not meet the agreed upon requirements. This agreement would then act as a kind of insurance for the AAM Connectivity Operator (Zubilevich et al., 2021), that somewhat redistributes the responsibility for the functioning of the service.

Additionally, the AAM Connectivity Operator will purchase some network infrastructure for themselves, including a core network. This will be provided by the Telecom Vendor. As discussed in the previous use case, this purchase has traditionally been in the form of a one-time fee, and so will probably continue that way due to it being considered common practice (Enders et al., 2019). However, a subscription model in which the Telecom Vendor provides continuous updates and support could also be possible, as that would accommodate for AAM Connectivity Operators with less technical expertise in running a core network (Enders et al., 2019; Tabares et al., 2023), and give the Telecom Vendor more predictable revenue (Enders et al., 2019; Ojala, 2013).

Terrestrial Network Operator

The Terrestrial Network Operator also purchases network equipment from the Telecom Vendor. This equipment has typically been purchased outright for a one-time fee, and this is likely to continue due to it being common practice (Enders et al., 2019).

Satellite Network Operator

The SNO's money flow in this use case is likely to be similar to that of the previous use case.

6

Conclusion

This purpose of this thesis was to conceptualise emerging business models in the integration of terrestrial and non-terrestrial networks within the context of 6G. Specifically, two distinct use cases were focused on, namely connectivity for rural and remote areas, and autonomous flying taxis. Through a combination of empirical research methods including interviews, workshops, and documents, value networks were developed for each use case. These value networks provided a holistic view of the interdependencies among actors, highlighting their roles, relationships, and interactions in facilitating the delivery of connectivity services. A focal actor was identified in each use case, and a business model canvas was developed to describe the business model for the specific entity. Lastly, indicative money flow models were proposed for each value network.

> *RQ1: In an integrated TN and NTN 6G scenario, what are the key actors and roles within the emerging value networks in i) connectivity to remote and rural areas and ii) connectivity for unmanned air taxi services?*

In the context of connectivity for rural and remote areas, it became evident that the 3GPP standard seems promising to provide a full connectivity solution to the vast device ecosystem, although experimentation also underway in proprietary and unmodified LTE solutions. MNOs emerged as pivotal players, poised to leverage their existing infrastructure and customer base to offer comprehensive connectivity solutions through subscriptions. However, uncertainties persist regarding the roaming interface between MNOs and SNOs. A new role, the 6G NTN Operator, was proposed to bridge this gap, facilitating seamless connectivity between terrestrial and satellite networks. The strategic motives of SNOs, MNOs, and other stakeholders were scrutinised, underscoring the potential for new revenue streams and the imperative for collaboration in shaping the future of connectivity services.

In the context of autonomous flying taxis, a new actor emerged: the AAM Connectivity Operator. Their primary function is to offer a comprehensive connectivity service tailored specifically for flying taxi operators and other AAM use cases. This entails the integration of terrestrial and satellite networks to deliver a seamless connectivity solution. Given the stringent requirements on connectivity for such service, AAM Connectivity Operators will need close collaboration with Terrestrial Network Operators and SNOs. Moreover, the deployment of new network infrastructure may necessitate substantial investments. This raises questions regarding the feasibility of joint investments between MNOs and AAM Connectivity Operators to meet the evolving connectivity needs of autonomous aerial mobility.

In addition to MNOs, SNOs, and new actors, Telecom Vendors, Chipset Manufacturers, and Device/Flying Taxi Manufacturers all stand to gain new business opportunities in both use cases. It's clear that the value network approach is useful for understanding the dynamics between the different actors. Close collaboration among multiple stakeholders is crucial to make the most of these opportunities and deliver the best solutions in both scenarios.

> *RQ2: For each case in RQ1, what elements will constitute the business model of the network focal?*

In the case of connectivity for rural and remote areas, the 6G NTN Operator was identified as the focal actor. This actor provides the necessary interface between MNOs and SNOs to enable the NTN service. Their customers are MNOs or MVNOs who they reach through direct sales channels, and offer close technical support to. Their main activities include maintaining and monitoring the network, as well as building the necessary infrastructure. They operate their own core network, along with certain parts of a RAN which they purchase from the Telecom Vendor. They can charge customers based on three dimensions; connection, data usage, and QoS. Their costs consist of purchasing a core network, RAN equipment, connectivity from SNOs, and overhead costs.

In the case for connectivity for autonomous flying taxis, the AAM Connectivity Operator was identified as the focal actor. They keep all flying taxis connected at all times per specific connectivity requirements. Their customers include different types of flying taxi operators, as well as other AAM use cases. They reach their customers through direct sales, and offer close support to ensure each customer receives the best solution. Key partners include TN Operators, SNOs, and Telecom Vendors. Their main activities revolve around dealing with partners to ensure network performance, enabling seamless handover, sales, and dealing with regulators. Key resources are access to networks of TN Operators and SNOs, their core network, and brand image.

They can charge their customers either on a recurring basis, or on a data usage basis. Their costs consist mainly of access to partners' networks, data usage, core network costs, and overhead costs.

> *RQ3: What are the potential money flows between the actors identified in RQ1?*

For connectivity for rural and remote areas, the main types of money flows between actors in the value network are envisioned to be recurring fees, pay-per-use, and one-time fees. The user pays for the NTN connectivity through a higher subscription fee from their MNO. The MNO in turn pays a recurring fee for access to NTN connectivity along a fee based on data usage to the 6G NTN Operator. This actor in turn pays the SNO for satellite capacity on a per-use basis. The rest of the payments including devices, chipsets, satellite equipment, ground infrastructure, launch costs, and satellite equipment are envisioned to be one-time fees in most cases.

For connectivity for autonomous flying taxis, similar money flow types are expected, with the addition of SLAs. The passenger pays the Flying Taxi Operator a fee for each flight. The Flying Taxi Operator pays a usage fee to UTM/U-Space Stakeholders as well as Vertiport Operators based on the number of flights. They also pay a fee for the connectivity service to the AAM Connectivity Operator, either based on usage or through a subscription. Owing to the high requirements on connectivity, the AAM Connectivity Operator will pay the TN Operator and SNO according to SLAs. Costs for flying taxi vehicles, chipset, and network equipment are expected to be one-time fees.

6.1 Future Research

Looking ahead, future research endeavors could delve into the actual monetary flows within these value networks to validate the viability of the proposed business cases for each actor. By scrutinising the financial intricacies of value creation and distribution, researchers can gain deeper insights into the economic sustainability and commercial viability of emerging connectivity use cases.

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Appendix: Interview Template

The following is the interview template that was used for semi-structured interview as well as focus group discussions. Data was collected based on current needs, and specific questions were shaped based on the current understanding of the researchers. Therefore, the interview guide consists of broad topics that were covered rather than specific questions.

Conditions related to each use case

- Technical requirements
- Infrastructure needs
- Necessary actors and roles
- Standardisation work

Current developments

- Existing solutions
- Strategic motives and intent of incumbent actors
- Challenges and opportunities
- Emerging actors

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF ENTREPRENEURSHIP AND STRATEGY
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

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