Developing an explanatory model for the firm investments in submarine optic telecommunication cables

A case study of the investment behaviour to the Netherlands and Spain

R. Kamerling

TU Delft

Ministerie van Economische Zaken en Klimaat

Developing an explanatory model for the firm investments in submarine optic telecommunication cables

A case study of the investment behaviour to the Netherlands and Spain

by

Rens Kamerling

Student number: 4097408

in partial fulfilment of the requirements for the degree of

Master of Science

in Complex Systems Engineering and Management

at the Delft University of Technology,

to be defended publicly on 05/06/2018

Graduation committee

Chair:	Prof. Dr. B.A. Van de Walle, Faculty of TPM, section Policy Analysis
First supervisor:	Dr. A.F. Correljé, Faculty of TPM, section Economics of Technology and Innovation
Second supervisor:	Dr. M.L.C. de Bruijne, Faculty of TPM, section Multi-Actor Systems
External supervisor:	R. N. Barker, MSc. Ministry of Economic Affairs and Climate Policy of the Netherlands, department Telecom market

Ministerie van Economische Zaken en Klimaat

Acknowledgements

This thesis is the final deliverable for the completion of the Master program Complex Systems Engineering and Management (Before: Systems Engineering, Policy Analysis and Management). It is the end result of my research at the Ministry of Economic Affairs and Climate Policy of the Netherlands and the Delft University of Technology. This work is intended for everyone who is interested in the investment behavior of firms in submarine communication cables.

Writing this Master Thesis proved to be challenging in terms of effort, persistence and knowledge. I would not have been able to complete this document without the help of a number of people, both personally and professionally.

In respect to my commission I want to thank my first and second supervisors Aad Correljé and Mark de Bruijne from the Delft University of Technology. Meetings with them gave me a lot of new insights and motivation. Their feedback also helped me to structure my research problem and to improve the quality of my research.

Next I want to thank the colleagues of the Telecom Market department of the Ministry of Economic Affairs and Climate Policy for giving me the opportunity to perform my graduation project in the Ministry. In particular I want to thank my external supervisor Robert Barker. I would not have made it without his feedback and support. I also really enjoyed our conversations about telecommunication and politics.

Furthermore I would like to thank the chairman of my graduation committee, Prof. Bartel van de Walle, for his input and guidance during the meetings.

Lastly I would like to thank my family and friends. My parents have always (financially) supported no matter what, I am very grateful for that. Also, thanks to my roommates, friends and sister who have made my study in Delft unforgettable.

Rens Kamerling
The Hague, May 2018

Image frontpage: Sps-cables.com

Summary of the thesis

There is an increasing demand for transit data worldwide, due to development in mobile computing and cloud services. (SubOptic; Submarine Telecoms Forum, 2016). For countries it is important to be well connected in the global internet infrastructure. High quality connections improve the performance of a country (OECD, 2003). About 95% of all the data transit in the world flows through submarine communication cables and therefore this type of infrastructure is important. The submarine optic cables that land in the Netherlands were constructed between the years 1996 and 2001. This means that new investments are required in the near future, because the average lifespan of a cable is 25 years. Therefore the Ministry of Economic Affairs and Climate Policy of the Netherlands is interested in the factors that influence the potential investments of submarine communication cables to a country. This information is useful evaluate policy options for submarine communication cables. The research question in the thesis is: '*What factors explain the investment decisions in submarine communication cables?*

The thesis creates an explanatory model which explains firm investment behaviour in submarine communication cables. First a brief introduction to the history, the technology and the repair construction and repair operations of submarine communication cables is created. Also an overview is created of the interconnectivity market. This is the basis for the rest of the analysis since it identifies the investors. Secondly the research framework was created. As a first step interviews were conducted with governments, interest groups and investors. Based on the outcomes of the interviews and industry documents a research framework was created by combining different theories that can explain the investment behaviour of firms. The chosen theories are; the resource-based view, transaction cost theory and the transaction cost regulation. The first theory, resource-based view, explains the behaviour of firms based on their individual resources. This perspective was very useful to understand the business model and investment strategies of telecom operators. This theory however could not explain the business model and behaviour of platform companies. That is why complementary to the resource based view the transaction cost theory was applied. With the use of this theory more understanding was created about the investment in submarine cables by content and application providers, which is part of a vertical integration strategy. The theory also highlights the effect uncertainty has on investment decisions of telecom carriers and content and application providers. Thirdly the transaction cost regulation theory analysed the particular nature of the interaction between investors and governments. From every sub-analysis factors were obtained based on the theory. These factors explain a part of the investment behaviour. The factors that together explain the investment behavior are put together to make a first version of an explanatory framework that explain firm investment behavior. The first version of the framework was validated via a small, focused comparative qualitative case study which compared the relative attractiveness between the Netherlands and Spain. In the last step of the research the developed framework and the comparative qualitative case study between the Netherlands and Spain is used as validation. It also

to provides policy recommendations for national governments and thus the Ministry of Economic Affairs and Climate Policy.

Below three sub questions of the thesis are answered:

- How does the interconnectivity market work and which actors are active on this market?

In the interconnectivity market companies sell and buy data transit services. The two types of market players that invest in submarine cables are internet service providers, such as British Telecom and Verizon and content and application providers (CAPs) such as Facebook and Microsoft. Most of the data transit flows through submarine communication cables. The technology of the submarine telecom systems is changing rapidly. Due to new types of modulation, improved signal repeaters and 'purer' fibres the capacity increased rapidly. However to even further increase capacity different types of multi-cored fibres and new types of modulation will be required in the future. In recent years most telecom operators chose to upgrade the dry plant of the cables system. However there is a technical and economic limit to these upgrades. Therefore new investments in the wet plants of submarine communication cables will be required.

- Which factors influence investments in submarine communication cables?

Table 0 on the next page lists all the factors that influence investments in submarine communication cables to a country. The list provides an overview of the factors that can be influenced by the government and the factors that cannot or barely be influenced by the government. There are regulatory, geographical, demographical and asset specificity issues. Content and application providers and telecom operators consider the factors of different relative importance. CAPs prefer to diversify their supply chain between their data centres. Telecom operators have different investment strategy and connect regions with a large demand for data transit to sell data transit services.

- Which of the factors can be influenced by the Ministry of Economic Affairs and Climate Policy to facilitate investments in submarine communication cables to the Netherlands?

The explanatory model that was developed in this study shows that national governments, like the government of the Netherlands, have a limited amount of policy options to influence firm decisions to invest in submarine communication cable landings. Table 0 shows the factors that can be influenced by a government.

The first policy option is to increase or decrease the 'guaranteed maintenance zone' for submarine cables. In the case of the Netherlands the government could restore the minimum maintenance zone from 500m to 750m on both sides of the telecom cables. The current maintenance zone of 500m is below the international industry standards. This created a disagreement between the Ministry and different telecom operators. The telecom operators argue that they cannot maintain and repair some of their cables which cross a windfarm at sea due to the decreased maintenance zone. Therefore the reduction of the maintenance zone might have a deterrent effect on willingness to invest in submarine telecom cables to the Netherlands, since there is a higher risk involved for the investors. However some telecom operators, such as British Telecom will be likely stay dependent on the Netherlands, due to factor geographical location in the explanatory framework. On the other hand the government can argue that a maintenance zone of 500m in some parts of the sea is unavoidable because of the lack of space. In other words it can be seen as an effect of the increase in activities in the coastal seas of the Netherlands. Following this line of reasoning one can say that the reduction of the maintenance zone can have provoked a positive effect. The reduction of the maintenance zone can provide an incentive for submarine telecommunication owners to work more compact and efficiently.

Table 0 – Explanatory model for firm investments in submarine communication cables to a country

Name of the criterion
Factors that cannot be directly influenced by a government
Price level of data transit
Number cables owned by CAPs
Non-used supply
Digital economic centers
Number of CDNs of CAPs
Increase in diversity of existing networks
Quality of terrestrial backhaul
Number of landing cables
Number of cables that were constructed before 2003
Convenience of the geographical location of the country
Factors that can be directly influenced by a government
Liberalization of the telecom market
Risk of cable failures
(Regulated) space for future cables
Degree of cable protection
Guaranteed maintenance zone
Government investment

A second option is to force users of the sea to work together for a more efficient spatial division. This could be forced by adding extra collaborative requirements for the obtainment of a permit for the construction in the sea close to the shore. An example of such cooperation is the construction of a corridor in future windfarms in the North Sea. In this way the scarce space at in the North Sea can be used more efficiently and cables could be more protected, which could lower the 'risk of cable failures'. Corridors might be an option to keep Amsterdam accessible for close submarine cable landings. However forced cooperation of stakeholders can add complexity to the permit procedure. Additional requirements in the permit procedure could increase the time required to obtain a permit since stakeholders have to work together. Furthermore it could create conflicts between stakeholders. For example, investors in new windfarms at sea could disagree about the requirements of the corridor with the telecom operators.

A third option of the government is to create policies to improve the business climate for datacentres. The explanatory framework in table 0 shows that datacentres could increase investments in submarine communication cables to a country. An assumption here is that datacentres will increase the demand of data transit. In this way datacentres can 'pull' new submarine communication infrastructure to a country. However this study did not identify the different policy options to improve the business climate for datacentres in the Netherlands. Also more research is required to evaluate the feasibility of this policy.

In short, this thesis provided an introduction to submarine communication cables and the interconnectivity market. Then an explanatory model was developed that explains the investments in submarine communication cables to a country. This framework was used for a qualitative comparative study between the Netherlands and Spain for validation. Based on the framework and the comparative study policy recommendations were formulated for the Ministry of Economic Affairs and Climate Policy of the Netherlands and other governments.

Table of Content

Table of Figures

Table of tables

Chapter 1: Introduction

1.1 Exploration of the problem

The amount of data businesses and consumers use is growing rapidly and is not likely to stop growing in the near future. The total data traffic volume worldwide is projected to grow 41.4% downstream and 44.8% upstream between the years 2016 and 2022 in west European countries (Dialogic, 2016). Downstream data traffic is defined as the data traffic that is received by data users over the internet and the upstream data traffic is the data that is transmitted by data users on the internet (Sen & Wang, 2004). The major drivers of the growth of downstream traffic are the emergence of online video and music services, cloud services and the emerging of other new online services. The drivers of the growth of upstream traffic are online back-up services, online videos, music and overhead capacity for stream services (Dialogic, 2016). The increased usage of internet services for business operations increase the dependency of companies on the internet infrastructure. The OCDE confirms this trend. It stated in 2003 that "ICT continues to have strong impacts on the performance" (OECD, 2003, p. 9) and "businesses, governments, consumers and key infrastructures increasingly rely on the use of information networks, which are often interconnected at the global level" (OECD, 2003, p. 91). In other words internet services are important for the productivity of firms. A study of 2011 confirms the correlation between the quality of internet infrastructure and firm productivity. Switching from dial-up access to broadband access increased the productivity of a firm with 7-10% on average independent of firm type (Grimes, Ren, & Stevens, 2011). Internet infrastructure with fast connections is an important condition for a competitive economy. However it is not sure whether the current improvements in the internet have the same effects on the productivity.

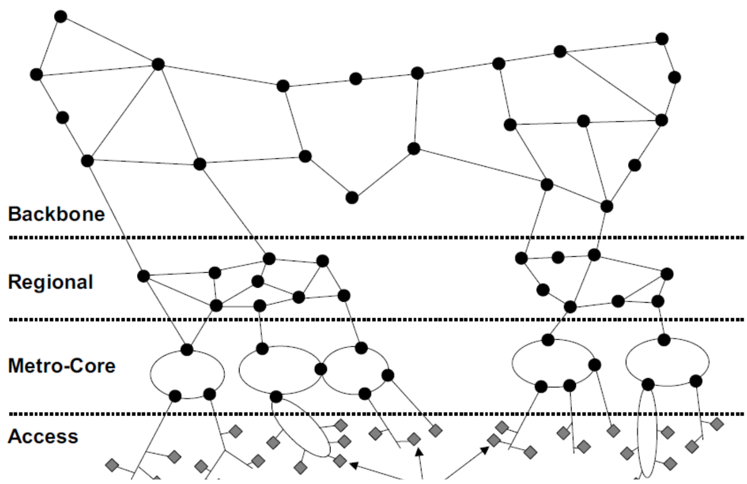


Figure 1 - Networking hierarchy based on geography (Simmons, 2014)

But how is the internet infrastructure structured? The internet infrastructure consists of a large number of networks which are interconnected. Figure 1 shows the structure of the internet from a geographical perspective. According to Simmons (2014) one way to look at the internet is to divide it in four geographical 'tiers' which are the access, metro-core, regional and backbone tier. The access tier connects the end users through a fine-meshed network. The next level is the metro-core tier which aggregates the traffic from the access networks. The metro-core networks are generally interconnected through the regional tier. Regional networks carry "the portion of the traffic that spans multiple metro-core areas, and is shared among hundreds-of-thousands of customers, with a geographic extent of several hundred to a thousand kilometres" (Simmons, 2014, p. 4). The data traffic between the regions is carried by backbone networks. Backbone cable connections can contain millions of customers and span thousands of kilometres (Simmons, 2014). The backbone connections are the digital highway for international data.

The global internet backhaul infrastructure consists of networks of optic fibres and internet exchange points. Internet exchanges are top level nodes within the global internet infrastructure where data traffic is concentrated and interconnected. The optic fibre cables of the backbone networks are both terrestrial and submarine. However about 95% of all data traffic worldwide flows through submarine communications cables (Sanger & Schmitt, 2015). The investment behaviour in submarine backhaul connections is the main topic of interest in this thesis.

The Netherlands locates both internet exchanges and submarine optic cable landings. This infrastructure connects the Netherlands directly with the global internet backhaul networks. One of the largest internet exchanges (IXs) is located in the Netherlands (AMS-IX, 2016). The 'AMS-IX' consists of servers that are located in and around Amsterdam. AMS-IX has a peak capacity over 5 terabits per second (AMS-IX, 2016). Also submarine optic cables which are part of the global backbone networks come ashore in Dutch coastal towns such as Domburg, Katwijk, Zandvoort, IJmuiden, Castricum and Egmond. For example the 'TAT-14' connects the USA, UK, France, Denmark, Germany France and the Netherlands (TeleGeography, 2017). For the Netherlands and other countries IXs and good backhaul interconnection can create a positive 'spill-over effect'. These infrastructures create an attractive business climate for investments in data centers, software companies (TNO; Dialogic, 2016). Internet exchanges and highly developed internet infrastructure provide easy access point in the global backhaul of the internet.

Most of the submarine telecommunication cables to the Netherlands were constructed between 1996 and 2001 and have an estimated twenty-five-year lifespan on average (TeleGeography, 2017). However in practice the exact life span of a cable depends on technical, operational, commercial, financial and legal factors (Suboptic, 2017). This could mean that a large share of the submarine data cables that currently connect the Netherlands might be put out of service within approximately four to nine years. Nearly all submarine communication cables that are connected to the mainland are in non-public hands (TeleGeography, 2017). The only exception is the COBRA-cable which is a cable between Eemshaven and Endrup which connects respectively the Netherlands and Denmark. This is a cable will be operational from the start of 2019. The Cobra cable is owned by Relined a subsidiary company of the state owned TenneT (Relined, 2017). However, this cable is an exception. In general backhaul infrastructure to and in the Netherlands is mostly private owned. (Policy Exchange, 2017). Private actors can decide when and if cables are renewed after the lifespan or not. (Coffen-Smout & Herbert, 2000).

1.2 Problem definition

The question is whether the current cables to the Netherlands will be renewed in the future? The submarine backhaul internet infrastructure is important for the Dutch business climate of the internet economy. Less submarine communication cables might reduce the high backhaul interconnectivity of the Netherlands. It is unclear which factors determine the investment behaviour of companies in submarine optic fibres. Understanding the investments in submarine cables and the strategies of companies is required because they can have effects on the business climate of countries. This is especially interesting from a governmental point of view.

In 2016 the Telecom Market department of the Ministry of Economic Affairs and Climate Policy of the Netherlands commissioned a research titled 'The Future of the Dutch Digital Connectivity' (Ministerie van Economische Zaken en Klimaat, 2016). The research was conducted by Dialogic and TNO discussed that: "the Netherlands has very good digital access because of submarine communication cables connections; however this dominant position might crumble down in the future" (TNO; Dialogic, 2016, p. 102). Therefore the Ministry of Economic Affairs and Climate Policy of the Netherlands wants to understand the investment behaviour of companies that invest in submarine optic fibres. Understanding of the investment behaviour provides a basis to evaluate future policies to influence the investment behaviour of investors. However it is unclear how the investments in submarine communication cables can be analysed. Which economic theory can explain the investments?

1.3 Relevance from a society perspective

The goal of the Ministry of Economic Affairs and Climate Policy of the Netherlands is "to improve the business climate and enhance the international competitiveness of the Netherlands" (Ministerie van Economische Zaken, 2017). Therefore the Telecom Market department of the Ministry of Economic affairs and Climate Policy wants to understand the factors that influence the investment behaviour of private actors that invest in submarine communication cables. Furthermore the ministry wants to understand whether it is necessary and how they could facilitate investments in cables that land in the Netherlands. This thesis which aims to answer these questions is relevant from the society perspective. It allows the government to make more substantiated policymaking regarding submarine communication cables.

1.4 Relevance from a scientific perspective

From a scientific perspective this study is relevant for different types of reasons. Currently there is no comprehensive economic theory that can explain the investments in submarine optic fibres of the market players. Therefore this study aims to identify the different types of factors that influence the investment decisions of the different type of investors. These factors are for example from a legal, geographic, technological or economic nature. By combining multiple economic theories to a framework this study creates a new perspective to understand and analyse the investments in submarine fibres. Multiple theories are used because they can provide different perspectives to explain the investments in submarine communication cables. The used theories are compared and their usefulness to explain the investments in submarine communication cables will be discussed. Also the applicability of the theories on the submarine communication cable industry is discussed. Based on the outcome of the analyse an exploratory model is created which can make underpinned and substantiated estimations about the investments to countries. In other words the model in can be used to understand the current investments to a certain country. It can also be helpful to anticipate on future investments. The explanatory model might also be used in future research to analyse investments in other network industries with government influence.

1.5 Research objectives

The goal of the research is to understand the investment behaviour of firms that invest in the submarine communication connections. Also a deeper insight is required in the investment motives and the factors that influence the investment decisions. In that way recommendations can be provided to the Ministry of Economic Affairs and Climate Policy.

The three research objectives in this thesis are:

- to understand the motives of the different type of actors that invest in submarine communication networks
- to understand which factors influence the decision making process for the investments in the submarine communications market
- to understand which factors governments can influence to change the investment behaviour of actors that invest in submarine communication cables

1.6 Research questions

The main research question is: '*What factors explain the firm investment decisions in submarine communication cables?*

The main research question is answered with help of the following sub questions:

1. How does the interconnectivity market function and which actors are active on this market?
2. Which factors influence investments in submarine communication cables?
3. Which of the factors can be influenced by the Ministry of Economic Affairs and Climate Policy to facilitate investments in submarine communication cables to the Netherlands?

1.7 Research approach and method

The first step of the research is chapter 2 which provides an introduction to the history, the technology, the construction and repair operations of submarine communication and the structure of the interconnectivity market. This is useful because it helps to understand which different types of investors are involved in the submarine communication industry market. In this way chapter two provides background information and a starting point for the subsequent chapters.

After the identification of investors in submarine communication cables the research methodology is created in chapter 3. Since there is no comprehensive economic theory available to explain the investments in submarine communication cables a new research framework has to be developed to explain the investment processes of submarine fibre infrastructure. The framework of de Vaan (2012) is the starting point of the development of the framework for analysis. This framework was developed to analyse the investment behaviour of investors in small field upstream gas fields in the Netherlands. The framework is useful because it provides an example of how theories can be combined analyse the investment behaviour of companies in a network industry with government intervention. In this way the framework provides a starting point for the development of an explanatory model. The framework of de Vaan (2012) will be adjusted to analyse the investment in submarine optic fibres with different economic theories.

The first step of the development of the framework takes place in chapter 3. It identifies relevant issues to explain the investments in submarine communication cables. Since there is limited literature available about which factors influence the investment behaviour in submarine optic fibres it is difficult to pick the 'right' theories. Therefore interviews are conducted with experts from the submarine industry to obtain information about which factors explain the investment behaviour of these stakeholders. The interviews are conducted with investors, civil servants and interest groups. From the interviews factors are identified which are used to be able to choose relevant theories for the framework. Choosing the relevant theories takes place in two steps. First the identified factors are contrasted with the theories used be Vaan (2012). In this way the relevancy of the theories used in the framework of de Vaan can be discussed. Relevant theories from the framework of de Vaan can also be used in the framework to explain the firm behaviour of investments in submarine communication cables. After that other theories are added to explain the remaining factors that are not yet addressed by the earlier chosen theories. After the selection process of the theories the relevant theories are operationalized which is done based on industry information and the earlier mentioned interviews with investors, civil servants and interest groups. By using multiple theories the research problem can be analysed with multiple perspectives. The use of different perspectives has two advantages. It allows creating a new perspective to understand the different factors which can determine the investment behaviour. Furthermore different theories might provide different explanations for the same phenomena. This can create additional insight.

In chapters 4, 5, and 6 the theories are applied separately to analyse the investments in submarine communication cables. Every theory explains 'a part of the puzzle'. In the end of every analysis chapter the strong and the weak points of the applied theory are discussed. Also a set of factors are identified based on the theory and analysis which can explain a part of the investments in submarine communication cables to a country. In chapter 7 the factors of chapter 4, 5 and 6 are merged into one list. This list of factors is used for a qualitative comparative case study between the Netherlands and Spain. A comparison between the Netherlands and Spain provides an opportunity to apply the explanatory model to compare the investments these two countries. Also it helps to discusses which factors are important to explain the investments in submarine cables and which are less helpful. The application of the explanatory model is also first validation of the model.

Chapter 8 and 9 are respectively the conclusion & discussion and the policy recommendations for governments based on the analysis and the explanatory model.

1.8 Thesis outline

Figure 2 shows the different research steps in the thesis.

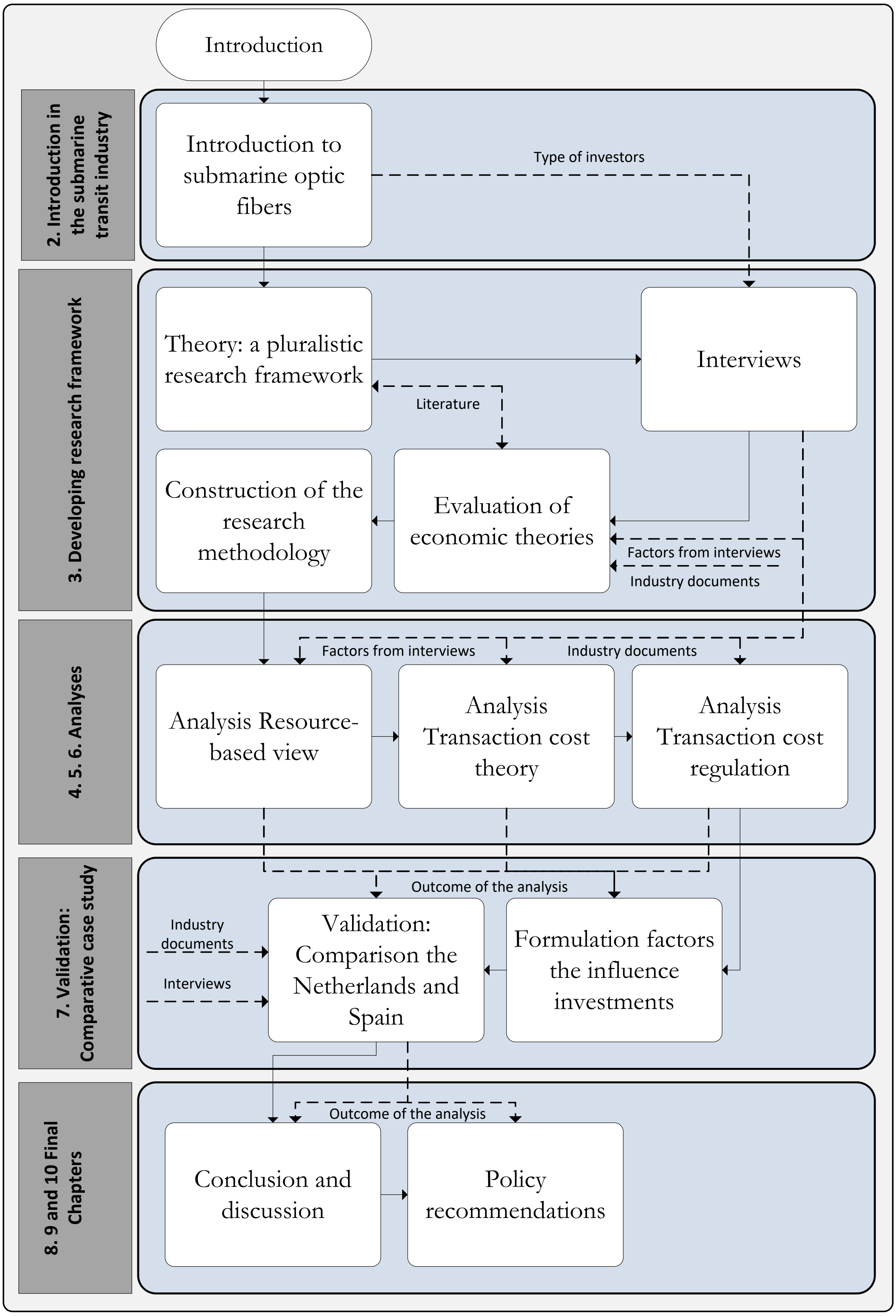


Figure 2 – Structure of the thesis (continuous line represents the steps, dotted line is the source of information that is used in the research step)

Chapter 2: Introduction to submarine optic fibers

Chapter 2 provides a brief introduction to the history, the technology and the construction and repair operations of submarine communication cables. In this way this chapter forms the basis for the rest of the analysis. In this chapter also an introduction is provided to the interconnectivity market. In this way the first research question is answered: **How does the interconnectivity market work and which type actors are active on this market?** The chapter has the following structure; first the history, the technological developments and the construction and repair operations of submarine optic fibers are discussed in 2.1, 2.2 and 2.3. Then in 2.4 an initial introduction to the interconnectivity market is provided. This identifies the different types of stakeholders that are active in the interconnectivity market and discusses their role. This analysis is input for the selection of the interviewees in chapter 3.

2.1 The history of global communication networks

In today's world the global optic submarine telecommunication network is the backbone of the internet. The network consists of a large number of submarine cables connecting different countries and continents (TeleGeography, 2017). The development of a global submarine telecommunication network started in 1858. In this year the first submarine communication cable was deployed by the Atlantic Telegraph Company which placed a telegraph cable across the Atlantic Ocean between the United Kingdom and the United States. Regrettably this pioneering cable broke down quickly. The connection was lost after a couple of weeks due to erosion of the cable (Clark B. , 2016). Since this first cable the technology of submarine telecommunication cables has been improving continuously. In 1956 new technology was introduced. In this year the first trans-Atlantic telephone cable was deployed, which could be used for telephone connections between the American and the European continents (Clark B. , 2016). However, the biggest improvement came in 1988 when the first Trans-Atlantic optic fibre cable was placed, the TAT-8. "Ownership was vested in ATT Co. 34 per cent, British Telecom 15.5 per cent and France Telecom 10 per cent, the remainder being taken up by other telecommunication administrations" (Bray, 2002, p. 244) The TAT-8 linked the United Kingdom, France, and the United States (Beaufils, 2000). Optic fibre technology strongly improved the information density which can be transmitted over cables. The TAT-8 "effectively doubled the existing cable capacity across the North Atlantic…" (Bray, 2002, p. 244). Optic fibre cables have large number of beneficial properties. Beaufils (2000) describes different reasons to explain why submarine networks are today the best choice for transmission of high capacity traffic between countries in comparison to satellite connections (Beaufils, 2000, p. 17):

- *"Capacity:* Submarine systems offer very high capacity. This capacity is much higher than any anticipated satellite system."
- *"Transmission quality:* There is real time transmission along with very low bit error rate offered by submarine cables contrast with satellite communications which add delay to

communications making interactive data transmissions difficult and supply a quality of transmission subject to external factors."

- *"Confidentiality:* Submarine transmissions offer undoubtedly the best confidentiality and security of transmission."
- *"Capacity upgrade:* To cater to increased traffic, it is relatively easy to increase the capacity of a submarine system during its lifetime by means of wavelength division multiplexing technology. It is almost impossible to do the same with satellite systems."
- *"Lifetime:* Submarine systems are designed to last for 25 years whereas satellite systems have a much shorter lifetime."
- *"Maintenance:* Maintenance of submarine cables is possible in the event of a cable failure. Satellite failure cannot be repaired easily."
- *"Civil engineering works:* A submarine equipment station is usually a relatively small room in which the terrestrial electronics equipment is located. Earth stations for satellites require larger room space and installation efforts."

Because of the large number of advantages in comparison with satellite data transfer the optic fibre submarine connections became the most used infrastructure for high capacity data traffic. Currently there are around 300 active submarine cables all around the world (TeleGeography, 2017). Figure 3 provides an overview on the cables in the North-Atlantic Ocean between the United States, Europe and parts of South America and Africa. It is evident that optic submarine telecommunication cables are vital for the internet. The next step is to understand how the optic fibre technology itself developed over the years. How did the submarine telecommunication network meet the rising demand in the last years? The technologies that made this increase in capacity possible in the past and future are discussed in 2.2

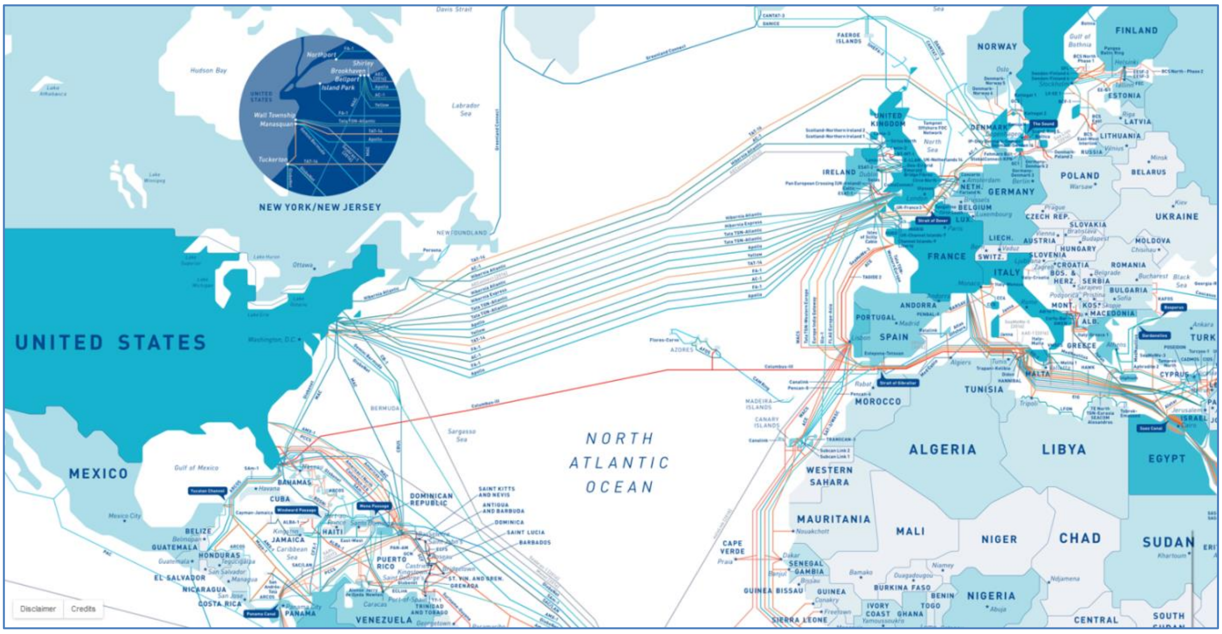


Figure 3 - Overview of submarine optical fibers between the United States, Europe, South America and Africa (TeleGeography, 2017)

2.2 Technological developments for optical fiber networks

In 2.2 he most important technologies that helped to reduce the costs per data unit and increased the capacity and flexibility of submarine communication networks are discussed. Why do have submarine fibres such a high capacity? Also, can this the capacity on one cable be increased even further in the future? The technologies in the chapter will not be discussed in detail; the aim of the paragraph is to get an overview of the latest technological developments and trends of technological improvements of submarine fibre cables.

2.2.1 Basic working of submarine fibers

In order to understand submarine cables systems it is helpful to divide them in two parts 'the wet plant' and 'the dry plant'. The dry plants are the terrestrial parts of the cable system that contains the emitting, receiving devices and most of the switches. The wet plant is the cable deployed in the water which links the different dry plants. Therefore the wet plants can be seen as the links with the dry plants as nodes in the optical network (Vusirikala & Kamalov, 2016). First the technology in both the dry plants and the wet plants are discussed. Although the technology from dry plant and wet plants are discussed separately in 2.2, in reality the plants are matched to each other and work as one system.

Dry plants of a submarine cable system

In the dry plants Wavelength Division Multiplexing (WDM) transponders and switching equipment are connected to the fibre cables. "WDM technology enables different light streams/wavelengths to be sent at different optical frequencies and multiplexes this (i.e., combined) onto a single fibre … Since 2000, over one hundred wavelengths per fibre can be generated providing a tremendous growth in network capacity" (Simmons, 2014, p. 2). Lasers produce the light streams with different wavelengths which are multiplexed (i.e. combined) and sent through the fibre cables from the terminal. Incoming signals first need to be 'demultiplexed' (i.e, separated) before they can be converted into other signals in the terminal. Wavelengths can also be 'switched' (i.e, redirected) to other cable connections. Nowadays this switching is mostly executed by switches that are equipped with 'optical-bypass technology'. This technology allows certain wavelengths to switch within the optical network with without leaving the optical domain. An example of an optical switch is a 'Reconfigurable Optical Add/Drop Multiplexer (ROADM), which can switch between two or more links, depending on the type of device. A ROADM can also add or convert wavelengths in the nodes without affecting the other wavelengths. Reconfigurable in this context means that the switching can be changed for different wavelengths dynamically. Optical switches are beneficial in comparison with the more old fashion electronic switches because they reduce the required electronic processing and the amount of switching equipment (Simmons, 2014).

Wet plants of a submarine cable system

The wet plant of the cable system is the fibre that connects the dry stations, which are also called links. Simmons (2014) states: "Links are depicted with just a single line, they typically are populated by one or more fibre-pairs, where each fibre in a pair carriers traffic in just one direction (It is possible to carry bi-directional traffic on a single fibre, but not common.)" (Simmons, 2014, p. 10). However along the way a part of the signal is lost because of dispersion and interaction with the fibre. Therefore: "Optical amplifiers may be periodically located along each fibre, especially in regional and backbone networks… Key enabler of cost-effective WDM systems was the development of the Erbium Doped Fibre Amplifier (EDFA). Prior to the deployment of EDFAs, each wavelength on the fibre had to be individually regenerated at roughly 40-km intervals, using costly electronic equipment. The EDFA optically amplifies all of the wavelengths on a fibre at once, allowing optical signals to be transmitted on the order of 500 km before needing to be regenerated" (Simmons, 2014, p. 2). EDFA enable submarine cable systems to send signals over very large distances though a fibre without the loss of signal.

The separation of the dry and wet plants makes it easier to scale up parts or the entire submarine telecommunication system. For example, it is possible to upgrade the WDM transponders in the terminal without upgrading the fibre itself. The 'upgraded' signal then is simply sent over the network increasing the total capacity of the system. However there are technical and economic limits to these dry plant upgrades. These limits are discussed in the next paragraph.

2.2.2 Technological of submarine optic cable networks until now

The previous paragraph summarized the basic working of an optical network and the required technology for high submarine communication systems. Since the first deployment of the TAT 8 in 1988, the first submarine fibre cable, the system improved rapidly (Beaufils, 2000). In this paragraph the developments in optical network technologies are discussed briefly. In the years

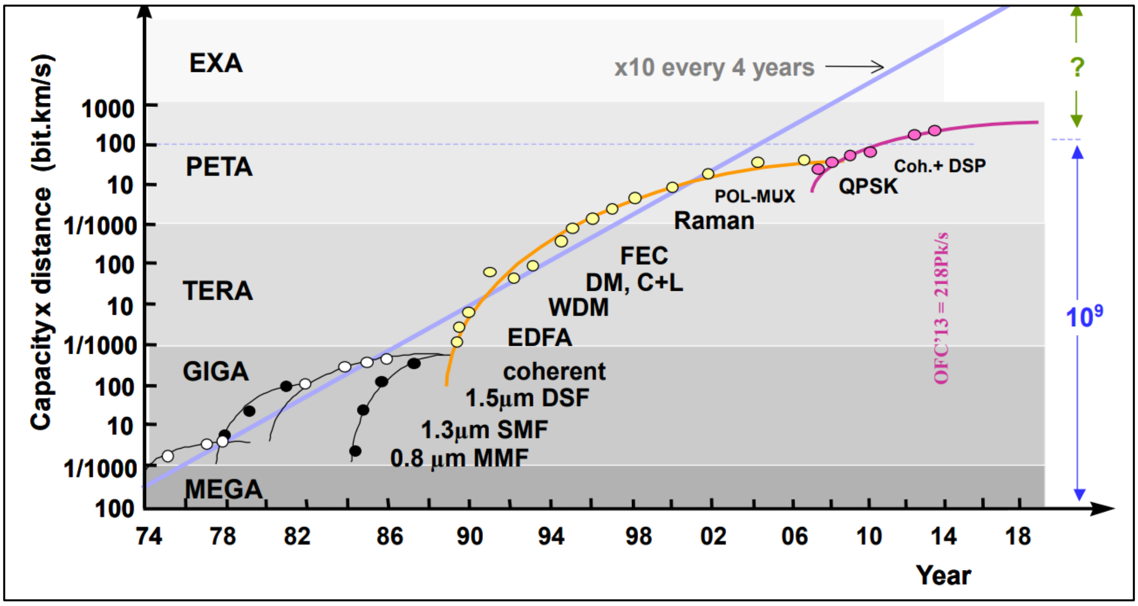


Figure 4 - Capacity improvements vs. Optical Moore's Law (Desurvire, Nakazawa, & Payne, 2013)

1995-2002 the capacity over one fibre increased from 1 wavelength x 5Gb/s to 42 wavelengths x 10 Gb/s over trans-Atlantic distances (Gautheron & Suyama, 2003). The main focus in this decade was to increase the capacity of optic networks. However this shifted in the years between 2003 and 2008. In these years the focus changed to achieve other improvements. According Gautheron (2008): "due to the collapse of the internet market within the 2002-2007 period, no new technologies have been deployed (for capacity increase. The objective during this period was not to transmit higher capacity but to reduce the system cost by reducing the repeater count.' This was accomplished by improving error correcting code efficiency, which helps to correct the incoming signals of low quality. Also the quality of fibres increased which reduced the dispersion of the signal in the fibre" (Gautheron, 2008, p. 1043).

In the last decade a lot of new advancements have been made regarding capacity improvements for submarine cables. The number of bits that can be sent through a fibre as a function of the distance has traditionally being following the 'Optical Moore's Law', which describes the exponential growth of data capacity per kilometres in fibre cables (Desurvire, Nakazawa, & Payne, 2013). However in the last years the increase in capacity is slowing down as showed in figure 4. This figure on the previous page shows that the technologies that were developed between the years 1974 and 2013 and the corresponding increase in capacity on a fibre. Examples of technologies are the earlier mentioned 'Wavelenght-Devision Multiplexing (WDM) and Erbium Doped Fiber Amplifiers (EDFA).

2.2.3 Current systems and future improvements of optical networks

What kinds of technologies are nowadays developed to improve the fibre cable systems? Vusirikala & Kamalov (2016) summarize new technologies for dry plants and the wet plans:

Dry plant improvements

For dry plants short term improvements can be achieved by implementing 'nonlinear compensation' of the optic signals. This technology corrects for the 'nonlinear noise' of high density signals thereby creating more capacity. Furthermore other types of modulation can create more flexible and higher density signals. However these new technologies alone will not be 'a game changer' to drastically increase in capacity to follow Moore's law for optical transition (Vusirikala & Kamalov, 2016). A law of physics called 'Shannon's law' proves that there is a theoretical limit of capacity that can be efficiently sent through a single fibre. Therefore new modulations alone cannot increase the capacity indefinitely (Vusirikala & Kamalov, 2016). In the future wet plant improvements are required to improve the capacity of submarine telecommunication systems.

Wet plant improvements

For wet plants ultra-low loss fibres were developed which 'provide a significant improvement'. In these cables there is less dispersion of the signal which leads to lower noise and higher signal preservation. Ultra-low loss fibres therefore enable longer distances for non-repeated cables. Another new technology is ROADM submarine branching. These units are optical switches which are located in the wet plant. This technology creates a more flexible network because of increased underwater switching possibilities. Also new types of underwater repeaters became available which increase the spectrum that can be amplified. An example of such a technology is a 'Raman Amplifier', also displayed in figure 4. The last improvement is the complete decoupling of the wet and dry plants. Decoupling has a couple of benefits such as easier management of the network that is connected with multiple data operators. This is possible through to use of open standards (Vusirikala & Kamalov, 2016).

Future developments

Vusirikala & Kamalov (2016) argue that future advances in capacity will consist mostly of a combination of improvements in the wet and the dry plants. Examples of possible future developments are the development of 'multi core fibres' and improved types of signal modulation. Multi core fibres, an increased number of fibres and better signal modulation can help to improve the capacity in the future with the use of 'spatial division multiplexing' (SDM). SDM uses multiple parallel signals in a single fibre. In this way the capacity limits of Shannon's law can be overcome. However this implies that future cables require new wet plants for large capacity improvements. For long term capacity improvements of submarine cable systems it is likely that the wet plants need to support SDM technology.

2.3 The construction and repair operation of submarine optic fibers

In 2.3 the construction and repair operations of submarine optic fibers are discussed. The goal of this paragraph is to create insight in the difficulties that are involved in the construction and repair operations.

2.3.1 Route survey and cable deployment

The deployment of a submarine is a process that can be divided into three different steps. These steps are respectively; route selection, route survey and cable deployment. Figure 5 provides an oversight of these steps. The third step, the cable deployment is discussed in two parts, the deployment in deep waters and in the deployment in shallow waters to the landing point of the cable. The three steps are discussed as in the report of the UNEP, WCMC and the International Cable Protection Committee (Carter, et al., 2009).

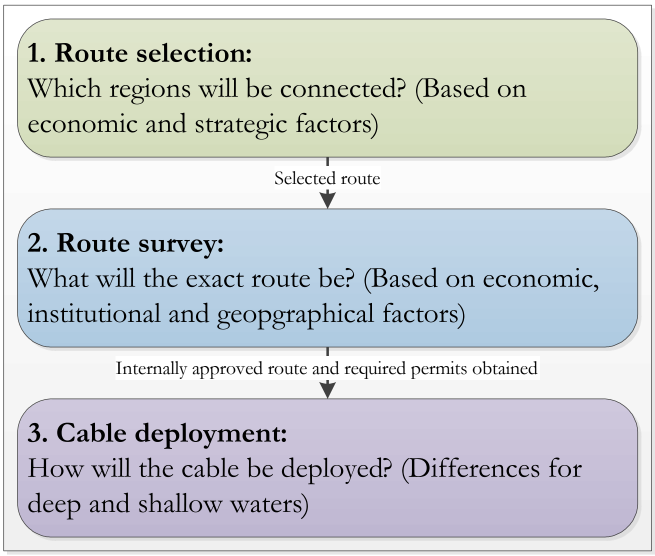


Figure 5 - Overview route survey and cable deployment own composition, based on (Carter, et al., 2009)

Route selection

The first step of the cable construction is the 'selection of the route', which means deciding which regions will be connected. For a private company this selection is made by the managers in the companies that invest in the submarine cable. The decision will be based on a number of different factors. The relevant set of factors for this decision is extensively discussed in the next chapters. During the route selection managers from the investing company have to take into account the marine geopolitical boundaries to avoid constraints for permits. These boundaries can be found in Global Maritime Boundary database (NASA, 2009). The UNCLOS United Nations Convention on the Law of the SEA (UNCLOS) describes "to what extend any coastal state controls cable-related activities within territorial seas and exclusive economic zones which apply to countries that ratified UNCLOS". If countries did no ratify UNCLOS, domestic regulations are applicable (Carter, et al., 2009).

Route survey

After the route is selected the second is step is to 'survey the route'. First researchers identify the exact landing stations for the future cable. A lot of factors influence the decision for the landing factors which will be discussed in later chapters as well. Nearly all of the submarine communication cables land on a beach, because of the convenience to land and bury the cable at the landing sight. As soon as the exact landing site is chosen a 'desktop study' is conducted to find 'the most effective route to the landing station'. This work will be executed by marine geologists with cable engineering experience. During the desktop study they analyse the relevant hydrographic and geologic information about the region, fisheries commission and permitting reports for cables in the past. Also the location history of existing nearby cables and other obstructions are reviewed. Based on the bundled information the specialist designs the optimal route for the new cable (Carter, et al., 2009).

After the optimal route has been chosen employees of the investing companies will visit and check the landing area. During this visit employees consult local officials to identify possible hazards for the cable close to the landing site. Besides that they also identify environmentally sensitive areas and permit procedures. In addition to the desktop survey a survey ship with 'multi-beam mapping system' is often used to identify water depth, seabed topography, sediment type, sediment thickness, marine faunal and floral communities and natural and human made hazards trajectory. Other optional measurements are the tide-effect, wave size and the movement of sediment. The survey ship obtains all this information by 'scanning' the seabed along the proposed cable route. For the seabed to 1500 meter depth a region of 1000 meter can be scanned. The exact requirements for the scans depend on the complexity of the seabed and possible local hazards for the cable such as trawl fishing or shipping activities. Armoured cables and dug cables might be required for these 'complex parts of the route' in shallow waters with water depths higher than 1500meter. The measurements will be used to adjust the optimal route and creates a viable route. (Carter, et al., 2009).

Cable deployment in deep waters

The cable deployment commences as soon as the viable route is approved internally and all the required permits are issued by the local governments. The cable is laid into the water from a cable laying vessel. Different factors affect the slope of the cable relative to the bottom. These factors are the speed of the vessel relatively to the ground, the speed of the unrolling of the cable from the cable ship and the sea depth. At first the laying vessel will unroll the cable slowly and simultaneously move slowly through the water until there is a touchdown of the cable on the ground. "Then the ship will accelerate to a practical maximum of about 11 to 15 km/hour. Periodically the laying vessel slows down to place the repeater through the cable handling machinery that controls cable tension and pay out speeds" (Carter, et al., 2009, p. 22). The lay-out speed is also determined by the slope of the seabed, since more cable is required for slopes. Modern cable laying vessels have constant monitoring systems for the determination of the position of the cable, the ground speed and the water depth. It continuously monitors the cable deployment progress on the route (Carter, et al., 2009).

Cable deployment from shallow water to the landing point

In deep waters the deployment of cables is quite straightforward. The cable is usually unarmoured and lying on the seabed in these parts of the sea. However this is not the case in shallow waters deeper than 1500 meters including cables. In these waters the cable requires protection for damage by other users of the sea. Sea ploughs and remotely operated vehicles (ROV's) are used to bury the cable below the seabed to protect the cable. For rugged areas stiff armoured cables are deployed with possibly additional protective covers of rock, concrete mattresses and steel or plastic conduits. After the deployment ROV's and divers inspect the cable for correct burial (Carter, et al., 2009). The cable will be connected to the landing terminal on land.

2.3.2 Repair operations

Cables that need to be repaired, replaced or removed need to first be recovered from the seabed. Repair is sometimes needed because of human or natural events that lead to failure or the breaking of the cable. Carter et all (2009) explain that retrieval of the cable is usually executed with specially designed grapnels deployed from the repair vessel. The recovery process is complex and depends on a set of factors such as speed, angle of recovery, the ships track along the cable route, drag of the cable, water depth, current velocity, wave effects on vessel motion and natural or human-made objects that potentially snag the ascending cable Other considerations are proximity of other adjacent developments, proximity of hazards, type of vessel, the existence of support vessels and the seabed type (European Subsea Cables Association , 2016).

2.4 An introduction in the interconnectivity market

The submarine optic fibres are used in the interconnectivity market. In 2.4 the structure and stakeholders in the value chain of electronic communication services is discussed. In paragraph 2.4.1 an overview of the different markets that are part of the value chain of electronic communication services is presented. The different stakeholders in the value chain are discussed in more detail. Then in paragraph 2.4.2 discusses the application layer of the value chain of electronic communication services Part of the application layer are the content and application markets. Subsequently paragraph 2.4.3 analyses the network layer in the value chain of electronic communication services. In this layer the internet access markets and the interconnectivity markets are located. In paragraph 2.4.4 includes a short overview of the different types of stakeholders is provided. This will be used in chapter 3 for the interviewee selection.

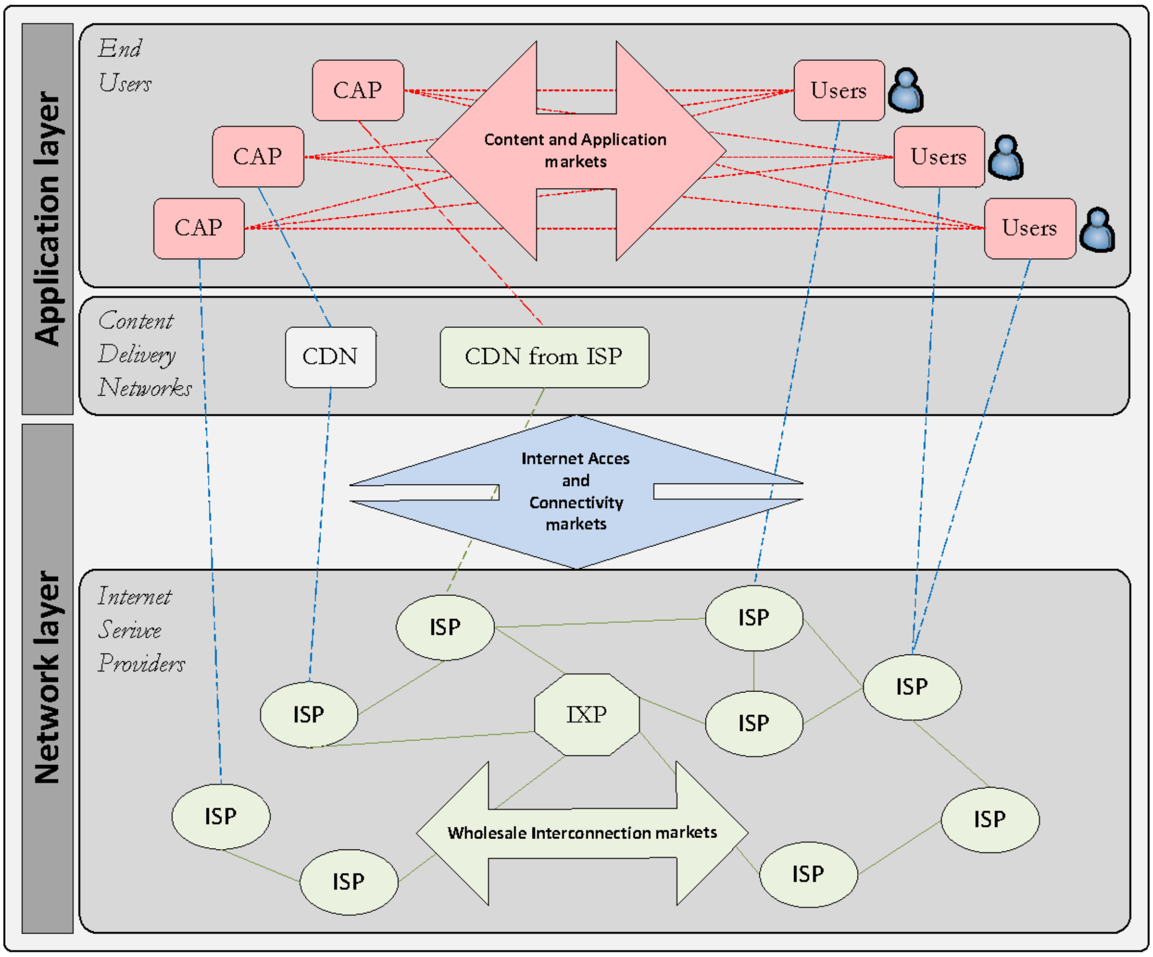


Figure 6 - Overview of the value chain of electronic communication services (Body of European Regulators for Electronic Communications, 2012, p. 9)

2.4.1 Structure of the value chain of electronic communication services

Figure 6 provides an overview of the value chain of electronic communication services. The overview displays the different stakeholders which are Content and Application providers (CAP), Users, Internet Service Providers (ISP), Content Delivery Networks (CDN) and an Internet Exchange Provider (IXP). The definition and the function in the value chain of these stakeholders are defined on the next pages. These definitions are based on the BEREC Report 2012 (Body of European Regulators for Electronic Communications, 2012).

First a definition is provided of the different types of stakeholders in the value chain of electronic communication services:

- **Content and application providers** are companies which create and aggregate content or applications as their core functionality. Examples of companies which are CAPs are Facebook, Google and Netflix. Their core functionality is the creation of content or an application/platform. However some large CAPs also invest in infrastructure such as own CDNs and backhaul connections such as submarine telecommunication cables. Therefore they are dependent on eye-ball ISPs to connect with the users. Eye-ball ISPs provide the access to the end-users of the internet. At the same time CAPs can also compete with ISPs by investing in own submarine telecommunication cable connections.
- **Users** of content and applications can be both businesses and residential users which consume content of CAPs through the internet. The content they use can be websites, videos, platforms, music services and more. Users' mostly downstream traffic from CAPs. However in recent years they also start to become producers of data themselves because of uploads on platforms and P2P traffic. This changed the download/upload ratio substantially in the last years.
- **Internet service providers** provide connectivity for different types of customers and are the stakeholder in the connection between CAPs and Users. 'Eye-ball ISPs' are the ISP which directly connect the end-users. These can be both residential users which require internet access services and business users which require connectivity. Sometimes an eye-ball ISP directly competes with CAPS with own 'over the top services' such as video on demand. A different type of ISP is the 'backbone ISP', which are international stakeholder. Regularly the business case of backbone ISPs is to peer with other ISPs and sell wholesale transit services to third parties. However it is possible that backbone ISPs also provide connectivity to large data end-users. An example of a backbone ISPs is Global Crossing, which owns also backhaul connections in the Atlantic Ocean. Large ISPs can be both eye-ball ISP and backbone ISP. Examples of such companies are British Telecom, Verizon and Telefonica. These ISPs have backhaul infrastructure and connections to the end-users. (Backhaul) ISPs own and invest in submarine cables.
- **Content delivery networks** are aggregators which they normally do on behalf of CAPs. A CDN is a caching service that saves content in the access network close to the user. In this way the quality of service can be improved and the load in the infrastructure is reduced. CDNs are usually only the cache servers without having own infrastructure. However some CDNs also do have their own network. For example, large CAPs such as Netflix also have their own CDN (Netflix, 2016).

2.4.2 The application layer and (IP)-interconnection

Figure 6 shows the different stakeholders in the value chain of electronic communication services. The value chain is not linear; the different stakeholders are dependent on one another in a network structure. Therefore the nature of the internet is very dynamic. A large part of the data traffic used the 'Internet Protocol'. An IP-connection is based on 'packet switches'. This means that information is being transferred in separated pieces of information through the network. The separated pieces can be sent via different routes through the network. The receiver can receive the separate pieces and combine them to restore the information. Therefore IP-connection is application agnostic in the network, the application layer is separated from the network itself (Body of European Regulators for Electronic Communications, 2012). There are also non-IP connections such as encrypted private connections.

CAPs can communicate easily with users on the application layer without having to deal with the network layer and the other way around. In figure 6 the application layer are the two top layers. The elements that are coloured red CAPs and users can have easy data traffic on the application layer. CAPs can provide/sell content to the users. But user can also use CAP platforms to sell products to other users for example on Amazon. CDNs are placed geographically close to the users for a high quality of service, as discussed earlier.

2.4.3 The network layer

The network layer is the down layer in figure 6. How can the network establish IP-interconnections between CAPs to the users and back? This connection is possible because both the users and caps are connected with ISPs. The ISPs themselves are also interconnected and form a network, as depicted in figure 6. But what are the relationships between the ISPs? There exist two types of IP connections between those stakeholders. These IP connections are transit and peering. Below the two types of IP-interconnection are defined.

- **Peering** "is the business relationship whereby ISPs reciprocally provide connectivity to each other's transit customers" (Norton, 2010, p. 1). "Peering does not include the obligation to carry traffic to third parties. The exchange of traffic typically occurs settlement free" (Body of European Regulators for Electronic Communications, 2012, p. 21). However other types of peering exist that have different conditions.
- **Transit** "is the business relationship whereby one ISP provides (usually sells) access to all destinations in its routing table with full connectivity" (Norton, 2010, p. 1). "This includes an obligation to carry traffic to third parties. Transit is a wholesale product against a payment" (Body of European Regulators for Electronic Communications, 2012, p. 20). Partial transit is applied when only a certain part of the internet can be reached through the transit service.

IP-interconnection between a CAP and a user and back is established through multiple connections between different ISP networks. First the CAP requires a connection between their servers and the ISP. The ISP creates a connection with the end-user. In general there are a number of possibilities to connect with an ISP.

1. A CAP can buy connectivity on the connectivity market in the form of IP-transit with an ISP. These are the blue links in figure 6. By buying IP transit the ISP has the obligation to carry the traffic to the users.
2. Large CAPs own CDNs and own or rent physical infrastructure that connects their servers directly with their CDNs. In this case CAPs need to buy IP-transit between the CDN and the end users. An example of infrastructure that is owned by a CAP is the submarine MAREA cable which connects the USA and Europe. Facebook who partly owns this cable has a direct connection to Europe through this cable (Microsoft, 2017).
3. Large caps peer sometimes CDN servers directly with an ISP on an internet exchange point (IXP). An IXP is a place where multiple ISPs and other networks can interconnect their respective networks on a central location (Body of European Regulators for Electronic Communications, 2012). In this way the CAP can reach the users through peering agreements. However it still requires a connection between the central servers and CDNs.

Secondly the ISP connects the CAP directly to the end-user or to other ISPs in the network. Individual ISPs have no direct connections with all of the end users. Therefore they peer with other ISPs or buy transit connections so that their network is interconnected to the internet. In figure 6 this is part of the network system which consists of the ISP boxes, which are coloured green. These interconnections are established in the wholesale interconnection markets. There are a variety of types of peering agreements and transit agreements between different types of ISPs. For example Atlantic Crossing, a backhaul ISP can charge American ISP for transit through a submarine cable crossing the Atlantic to European customer. ISPs can have a large number of peering and transit agreements with different ISPs. They can individually connect their networks or do this at central points, the IXPs. After one or more switches between ISP networks the connection is established to the ISP that connects to the end-user.

The last part of the connection between a CAP and users is the connection between the eye-ball ISP and the users itself. 'Eyeball ISPs' provide internet access to the users and in return users have to pay the eyeball ISP a fee from time to time to retain their internet access. In figure 9 this connection is the blue coloured link between ISPs and users.

2.4.4 Summary of the different types of stakeholders

Paragraph 2.3.1 showed that the interconnectivity markets are part the value chain of electronic communication services. This value chain contains both an application and a network layer. In the application layer there are transactions between CAPs and users. Users consume content or use applications which are provided by the CAPs. The IP-connection between CAPs and users flow through the network layer. In this layer there are different markets. In the connectivity markets connectivity is provided by ISPs to CAPs. In the internet access market internet access is sold by the eyeball ISPs to the users. The ISPs can provide connectivity to CAPs and internet access to users because they are interconnected. In the wholesale interconnectivity markets the contracts for this interconnectivity between ISPs and large data users are determined. This can either through transit or peering agreements.

The infrastructure is part of the network layer in figure 6. Users do not own infrastructure. CAPs usually obtain interconnection through ISPs. Therefore ISPs own and invest in the infrastructure. Eyeball ISPs own mostly the infrastructure at a local level. They provide the internet connections to the users through local fine-meshed networks. Backhaul ISPs own the backhaul of the internet on an international scale. In practice there is not a clear distinction between eye-ball ISPs and backhaul ISPs since large ISPs can do both functions. Part of the backhaul connections are the submarine telecommunication cables. However ISPs are not the only stakeholders that invest in submarine telecommunication cables. In the last years large CAPs such as Facebook and Microsoft also started to invest in submarine telecommunication systems. In this way they can connect their CDN servers through infrastructure that they rent or own.

In the next chapter the ISPs and CAPs among other stakeholders are interviewed to understand the relevant factors to explain the investments in submarine cables.

Chapter 3: Developing the research framework

After the introduction to submarine telecom cable technology and the interconnection market the research framework will be developed. Since there is no single theory that can be used to investigate and explain the investments in submarine communication cables a research framework has to be developed. The framework consists of a number of different economic theories which together explain the investments in submarine cable connections to countries. Chapter 3 identifies the relevant factors that explain the investments. Based on these relevant factors theories are chosen and used to construct the research framework

3.1 Overview of chapter 3

In 3.2 the development of the research framework starts. In this paragraph the 'methodological interactionistic framework' of the Vaan (2012) is taken as a starting point for the analysis. The framework is useful because it provides an example of how theories can be combined to analyse the investment behaviour of companies in a network industry with government intervention. Currently there is no economic theory that can explain well the investments in submarine cable, which is explained in more detail in 3.2.2. Therefore a combination of theories is chosen which can explain different factors that influence the firm investment behaviour. Furthermore in 3.2 the underlying theories which are used to evaluate and combine the economic theories for analysis are discussed. In 3.3 the interviewing process and provides an overview of the factors that influence the investment behaviour according to the stakeholders are presented. Then in 3.4 based on the factors from the interviews the theories are chosen. Here the theories of the framework of de Vaan (2012) are taken as a starting point. These theories are contrasted with the outcomes of the interviews. In this way the usefulness of the theories used by de Vaan can be discussed. Theories that are useful to explain the investments behaviour in submarine communication cables will be used in this study as well. For the remaining factors new theories are introduced. Eventually the chosen theories are combined. This creates the research framework of this thesis, which is presented and operationalized in 3.5. The last paragraph of the chapter provides a scientific reflection on the selection of the theories.

3.2 Underlying theories to build the research framework

3.2.1 Definition of a framework

The framework that will be developed in this chapter is a combination of several theories. Different theories can explain the same investment behaviour, but from a different theoretical perspective. However as a start the 'framework' and 'theory' itself have to be defined. In other words, what is the difference between a framework and a theory? Ostrom provides explains the difference between those two elements.

Ostrom (2011) defines a framework as "…the most general forms of theoretical analysis. Frameworks identify the elements and general relationships among these elements that one needs to consider for institutional analysis and they organize diagnostic and prescriptive inquiry. They provide a general set of variables that can be used to analyze all types of institutional arrangements. Frameworks provide a metatheoretical language that can be used to compare theories. They attempt to identify the universal elements that any theory relevant to the same kind of phenomena needs to include" (Ostrom, 2011, p. 8). On the other hand there are theories. "…theories enable the analyst to specify which elements of a framework are particularly relevant to particular question and to make general working assumptions about the shape and strength of these elements. Theories make assumptions that are necessary for an analyst to diagnose a specific phenomenon, explain its processes, and predict outcomes. Multiple theories are usually compatible with one framework. Economic theory, game theory, transaction cost theory, social choice theory, covenantal theory, and theories of public goods and common-pool resources are all compatible…" (Ostrom, 2011, p. 8)

3.2.2 Starting point, the Methodological Interactionistic Framework

Figure 7 shows the methodological interactionistic framework that is the starting point for the development of the research framework in this thesis. This framework is a logical starting point because it addresses investment behaviour in the gas market which has the same industry characteristics as the submarine optic infrastructure industry. Both industries are network industries with government interference such as access regulations.

Why using a framework to analyze the investments in submarine communication cables?
The selection of the methodological interactionist framework of de Vaan (2012) as a starting point is the result of a search for a relevant economic theory to explain submarine communication cable investments. However the search for such a comprehensive economic theory to explain the investments in submarine cables was not fruitful. For example, Google Scholar search engine was used to search "infrastructure industry" AND "investment behavior". First hit for this search is the paper "Broadband investment and regulation: A literature review" (Cambini & Jiang, 2009). This paper provides an overview of all the studies which investigate the broadband investment and regulations. However no comprehensive theory was found which can explain the effect of different factors such as demography, geography, firm characteristics. Also in the other 36 search results no relevant comprehensive economic theory was found which could be used to explain the firm investment behavior in submarine communication cables. Therefore the decision was made to develop an own research framework to analyze this problem. In this way different economic theories can be combined which can separately analyze different factor that are relevant for this submarine communication cables.

The methodological interactionistic framework was developed by de Vaan (2012). The framework consists of four elements that explain a part the investment behaviour of firms in an industry based on different levels of detail. The framework was developed to analyse the investment behaviour in small gas field in the Netherlands. The four elements in the framework are the contextual, investment, contractual and firm characteristics. Together these four elements describe the investment behaviour of companies.

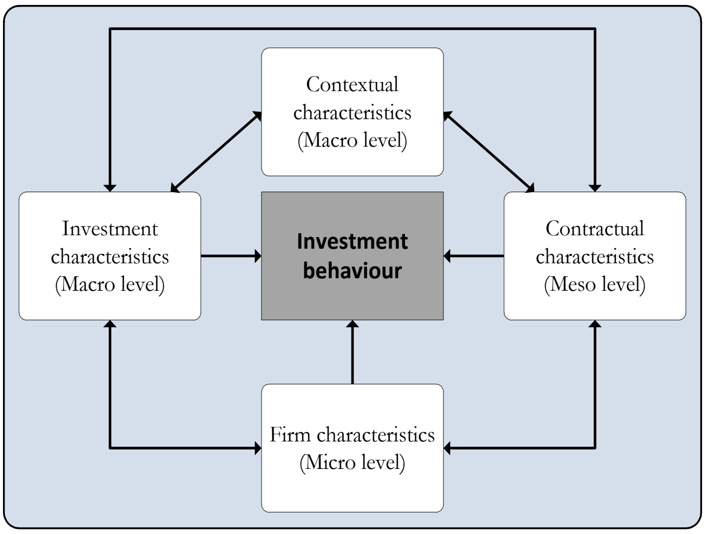


Figure 7 - Methodological Interactionistic Framework for Analysis (Vaan de, 2012)

The underlying assumption of the framework is methodological interactionism. (Vaan de, 2012). Methodological interactionism is a combination of methodological individualism and methodological holism, which recognizes that both individuals and larger social structures are relevant when explaining the behaviour of institutions Groenewegen et al. (2000). Methodological interactionism might be useful because elements with a high level of detail and low level of detail factors can be taken into account in the framework. However it is not sure if this distinction is useful to explain the investments in submarine cables. Methodological interactionism is combined with a 'pluralistic approach'. According to Groenewegen and Vromen (1996): "…formulating an all-embracing, all-condition theory is infeasible. The principal reason is that any of these theories is applicable under different conditions. If some theories can be assumed to be applicable under different conditions, they can be said to be complementary. In combination these theories then can be said to give us a riches understanding of some set op phenomena. Such theories can also be seen as complementary rather than conflicting or supplementary". The different elements of a framework can be filled in with different theories to explain the investment behaviour. By using multiple theories a more rich understanding can be created of the investment behaviour of companies due to the use different theoretical perspectives.

However how can the proposed theories for analysis be evaluated? The theories can be compared based on the issues that they explain and the conditions under which the theories are applicable (Groenewegen & Vromen, 1996; Vaan de, 2012). These conditions are based on the underlying assumptions of the theory. Interviews that are described in 3.3 try to identify the relevant issues and conditions. The framework that is developed in this thesis accepts that the different theories that are used have different underlying assumptions. Theories that will be evaluated are theories which can help to explain the behaviour of firms.

Paragraph 3.3 identifies the factors that are important to explain the investments in submarine communication cables. These factors are identified with interviews and are the basis for the election of the theories.

3.3 Interviews

In order to identify the important factors that explain the investments in submarine communication cables interviews are conducted with civil servants and contacts in companies that invest in submarine communication cables. In 3.3.1 the interview method is discussed. After that in 3.3.2 the choice for interviewees is discussed. Lastly in paragraph 3.3.3 an overview is provided of all the factors that were identified in the interviews.

3.3.1 Interview methodology

The goal of the interviews is identify which factors are important for the investment behaviour and which barriers and procedures have to be taken. This is done based the opinion of experts obtained through the interviews. For the interviews a qualitative 'semi-structured interview method is chosen'. In a semi-structured interview: "the researcher has a list of questions or fairly specific topics to be covered, often referred to as an interview guide, but the interviewee has a great deal of leeway in how to reply. Questions may not follow on exactly in the way outlined on the schedule. Questions that are not included in the guide may be asked as the interviewer picks up on things said by interviewees. But, by and large, all the questions will be asked and a similar wording will be used from interviewee to interviewee … In both cases, the interview process is flexible. Also, the emphasis must be on how the interviewee frames and understands issues and events—that is, what the interviewee views as important in explaining and understanding events, patterns, and forms of behaviour." (Bryman, 2012, p. 471). An example of an interview guide that is used in the interview with Microsoft can be found in Appendix B. The interview guides for interviews with other investors and organisation have the same type of structure. Main point of the interviews is to focus on identify which factors will have to be explained by the theories to explain the investment behaviour of firms to the Netherlands and Spain. Furthermore the interviews aim to identify possible barriers for cable investments.

3.3.2 The selection of submarine communication cable experts for the interview

The next step in the research is to select the expert for interviews. The interview with the investors will help to identify the factors that are important to understand the investment behaviour of companies and the barriers they face. These factors then are categorized and based on these factors a set of requirements for the research framework can be formulated. Since the goal of the framework is to compare investments to the Netherland and Spain the interviews are conducted with experts that currently already have investments in one or both of these countries or that work for a relevant institution or government in these countries. The outcomes of the interview will help to identify issues which should be addressed by the theories in the analysis.

First the investors in cable to the Netherlands and Spain have to be identified. The second step to make a selection of the investors that will be interviewed. Table 1 lists all the cables that land in the Netherlands and their closest landing.

As can be seen in table 1 the Netherlands has thirteen submarine telecommunication cable connections. Most of the submarine telecommunication cables are between the Netherlands and the United Kingdom. Investors that own two or more telecommunication cables that land in the Netherlands are British Telecom, KPN, CenturyLink and Verizon. British Telecom is the former incumbent of the United Kingdom and owns several cables that land in the Netherlands. Three cables are fully or partly owned by British Telecom such as the Farland and the TAT14. KPN is the incumbent from the Netherlands. This company is part of two consortia of cables that land in the Netherlands. CenturyLink and Verizon both own two cables. They both own one submarine cable completely by themselves. There are two trans-Atlantic cable systems that land in the Netherlands, which are the 14th Trans-Atlantic Telecommunications (TAT14) and the Atlantic Crossing 1 (AC1). These cables connect the Netherlands and different other countries of Europe directly with the United States.

Table 1 - Closest submarine telecommunication cable connections with the main land of the Netherlands. Based on: (Mahlknecht, 2017), (TeleGeography, 2017).

Cable name:	Company:	Ready for service:	From:	To:
Farland	British Telecom	1989	Domburg	Aldeburgh UK
TAT14	Consortium*	2001	Katwijk	St.Valerie FR
TAT14	Consortium*	2001	Katwijk	Norden DE
Concerto	Interoute	1999	Zandvoort	Zeebrugge BE
Circe North	Consortium**	1999	Zandvoort	Lowestoft, UK
Concerto	Interoute	1999	Zandvoort	Sizewell UK
Ullyses 2	Verizon	1997	IJmuiden	Lowestoft, UK
AC1	CenturyLink	1998	Beverwijk	White Sands Bay UK
AC1	CenturyLink	1998	Beverwijk	Westerland, DE
UK-NL 14	Consortium***	1996	Egmond	Winterton-on-Sea UK
Pangea South	Alcatel Submarine	2001	Egmond	Lowestoft, UK
TGN	Tata Communications	2002	De Marne	Humanby, UK
COBRAcable	Consortium****	2019	Eemshaven	Endrup, DN

Consortium*:	British Telecom, Verizon, Deutsche Telekom, Orange, Sprint, TeliaSonera, CenturyLink, KPN, Telenor, Etisalat, OTEGLOBE, SingTel, KDDI, Softbank Telecom, Zayo Group, Portugal Telecom, Slovak Telekom, TDC, Telus, Tata Communications, Telefonica, AT&T, Proximus, Elisa Corporation, Cyta, Rostelecom, Vodafone
Consortium**:	VTLWavenetdf, euNetworks
Consortium***:	British Telecom, KPN, Vodafone
Consortium****:	TenneT (Relined), Energinet.dk

There is one new cable which is the COBRAcable, which connects the Eemshaven in the north of the Netherlands with Denmark. This cable is developed by Relined a subsidiary company of TenneT. TenneT is the national grid operator of the electricity infrastructure of the Netherlands and is in public hands.

Table 2 displays the submarine telecommunication cables that are land on the peninsula of Spain. Telefonica owns 9 cables of which the Pencan 6, 7, 8 cables are the submarine connection between Spain and the Canary Islands. Telefonica also has investments in the Columbus III and through their subsidiary Telxius in the MAREA cable.

Table 2 - Closest submarine telecommunication cable connections with the main land of Spain. Based on: (Mahlknecht, 2017), (TeleGeography, 2017).

Cable name:	Company:	Ready for service:	From:	To:
TGN-Western Europe	Tata communication	2002	Bilbao	Highbridge, UK
MAREA	Consortium	2018	Bilbao	Virginia Beach USA
Pencan-6	Telefonica	2011	Conil	El Médano ES
Pencan-7	Telefonica	2011	Chipiona	Alta Vista ES
Pencan-8	Telefonica	2011	Conil	Candelaria ES
Pencan-9	Telefonica	-	Chipiona	Tarahales, ES
Columbus-III	Consortium**	1999	Conil	Caracvelos, PT
Columbus-III	Consortium**	1999	Conil	Mzara del Vallo, IT
Canalink	IT3	2011	Rota	Asilah, MA
Canalink	IT3	2011	Rota	Canary Islands ES
FEA	Global Cloud Xchange	1997	Estepona	Porthcurno, UK
FEA	Global Cloud Xchange	1997	Estepona	Palermo, IT
Estepona-Tetouan	Consortium***	1994	Estepona	Tétouan, MA
ORVAL	Algerie Telecom	2018	Valencia	Oran, AL
Balalink	IslaLink	2001	Valencia	Palma ES
PENBAL-5	Telefonica	1994	Gavá	Ses Covetes ES
BARSAV	Consortium****	1996	Barcelona	Savona, IT

Consortium*:	Facebook, Microsoft, Telxius (substitute Telefonica)
Consortium**:	Telecom Italia Sparkle, AT&T, Verizon, Telefonica, Portugal Telecom,
Tata	
	Communications, Ukrtelecom, Telkom South Africa, Telecom Argentina, Instituto Costarricense de Electricidad, Embratel, Cyta
Consortium***	Telefonica, Maroc Telecom
Consortium****	Telefonica, Telecom Italia Sparkle

These two cables are trans-Atlantic cables which connect Spain to the United States. The FEA cable of Global Cloud Xchange connects Spain with countries in the middle-east all the way to south-east Asia. The MAREA cable is a special cable because it is the first connection transatlantic-connection which is owned by a consortium of mostly CAPs, namely Microsoft and Facebook. The other submarine telecommunication cables are connections with the UK, the Balearic Islands, Morocco and Algeria. These connections are owned by different companies and consortia as seen in table 2. Verizon, Tata communications and Telefonica are the only three companies that own cables which have landings in all the Netherlands and Spain. Table 3 shows the connection of Verizon and Telefonica that land in both countries.

Table 3 on the next page provides an overview of the investors of cables that have been interviewed. The investors that are interviewed have either investment in a submarine telecommunication cable to the Netherlands, Spain or both. British Telecom, KPN and Telefonica are the three incumbents and still have infrastructure. Verizon is a global ISP with connections to the Netherlands and Spain and for this reason this country is also part of the interviews. Microsoft and Facebook have also been interviewed since they are the only CPAs with submarine telecommunication cable to Europe, specifically to Spain. Lastly Relined was interviewed because this party is the only investor in a new submarine cable landing in the Netherlands in seventeen year. Moreover they are the only public funded investor, which makes it a different type of investment.

Table 3 - Contacts of the investors of Submarine Telecommunication cables to the Netherlands and Spain

Company name:	Cables that land in Netherlands:	Cables that land in Spain:	Type:	Contact:
British Telecom	*Farland North,* *TAT14* *UK-NL 14*		ISP (Former Incumbant)	*G. Rea*
KPN	*TAT14* *UK-NL 14*		ISP (Former Incumbant)	*M. van der Paard* *P. Knol* *R. Dinkelman*
Telefonica/ Telxius	*TAT14*	*Pencan-6* *Pencan-7* *Pencan-8* *Pencan-9* *Columbus III* *Estepona-Tetouan* *PENBAL-5* *BARSAV* *MAREA*	ISP (Former Incumbant)	*A. Moreno Rebollo* *J.A. García Cabrera*
Verizon	*TAT14* *Ullyses 2*	*Columbus III*	ISP	*P. Booi*
Microsoft		*MAREA*	CPA	*J. de Groot* *D. Crowley*
Facebook		*MAREA*	CPA	*M. Violari*
Relined	*COBRAcable*		Public Fibre Carrier	*R. Weijers*

The aim was to have different type of investors with cables to both Spain and the Netherlands. Existing contacts between the Telecom Market department of the Ministry of Economic affairs and climate policy were helpful to get into contact with the right employees in the organization. The template invite for the interviews can be found in Appendix A. Mr. Crowley from Microsoft and Ms. Violari of Facebook has been contact through a conference call, since they work in the United States. The contacts from Telefonica and Verizon have also been contacted through a conference call.

Besides the investors also interviews were conducted with public servants in the government institutions of the Netherlands and with interest group(s). Table 4 shows the interviewed contacts in these organizations.

Table 4 - Other interviewed submarine telecom cable experts

Name of organization:	Type of institution:	Contact:
European Subsea Cables Association (ESCA) / Palagian	*Interest group / Consultant*	*T. Fisk*
Fibre Carrier Association NL|DC	*Interest group*	*R. van Fucht*
Saba Statia Cable System B.V	*Government of the Netherlands*	*W. de Haan*
Ministry of Economic Affairs and Climate Policy	*Government of the Netherlands*	*M. Botman* *J. Vermeulen*
Rijkswaterstaat	*Government of the Netherlands*	*R. Duijts*

3.3.3 Outcomes of the interviews

Apendices C to O summarzie the results of the interviews. From the transcription of the interviews with the investors the factors are extracted that explain the investment behaviour according to the interviewees. Table 5 shows the factors that were identified in the interviews.

Table 5 - Identified factors to explain investment behavior in submarine cables to a country

Verizon	Telefónica/Telxius
Risk of cable failure on a route	Estimations of data demand in an area
The location of wind farms at sea	Availability of investment partners
Latency of a route	CAPEX funds of the company
Number of datacenters in a country	Agreement with a consortium
Available space in the sea for new cables	Latency of a cable
Easiness of maintenance for cables	Availability of backhaul connections close to the shore
ESCA/ ICPC/ NASCA recommendation compliance of a country	Number of datacenters in a region
Geographical location	Reliable energy supply
Existing backhaul network	Shore characteristics
Influence by politics (e.g. Effects Brexit)	Shape of the ocean floor on a route
Access of the market	Risks due to environmental factors (hurricane/tsunami)

Amount of economic activity in an area	Permit application procedure in a country
Shore characteristics	Capacity of a new submarine fiber
Fishing activity	Shared strategy of Telefónica and Telxius
Availability of backhaul connections close to the shore	Developments in the digital landscape
Number of inhabitants of a country	Co-opetition' with other market players
Number of exiting cables on the same route	Environmental protection legislation
Geological activity in an area	Internal regulations
Shipping activity in an area	
Business strategy of Verizon	
Existing data capacity on a route	
Regionalization of the internet	
Repair time of a cable in an area	
Diversity strategy, make network resilient	
British Telecom	**Microsoft**
Current network assets of British Telecom	Location of the own datacenters
Economic and financial importance of a region	Current submarine cables of Microsoft
Risks of a cable cut on a route	Reliability of the connections between the databases
Shore characteristics	Estimation of future data capacity requirements
Backhaul connections in the region	Location of landing station
Costs to maintain the cables	Availability of partners for investments
ESCA/ ICPC/ NASCA recommendation compliance of a country	Low cost high capacity in the future
Wind farms at sea which are a barrier	Geography of the country
Total costs of a new submarine system	Interconnectivity of a country in the global network
Length of the route	Latency on a route
Latency on a route	Shipping activity on a route
Easiness to reach the shore	Seabed properties
Capacity demand in a region	History of uptime of existing cables on a route
Tax breaks regulations	Existing submarine connections to a region
Existing infrastructure of other owners on a route	Environmental regulations
Strategy of British Telecom	
Geographical location of a country	
Facebook	**KPN**
Future data demand of the Facebook products	Estimation of the demand in international data transit
Location of the current cables of Facebook	Latency on a route
Location and backhaul connections to Facebook datacenters	Geographical location of a country
Current capacity between data centers	Risks of cable failure
Availability of terrestrial backhaul close to the shore	Fishing activity
Seabed properties	Shipping activity
Fishing activity	Availability of a consortium
Existing cables on a route	Location of windfarms at sea
Risk for cable failure on a route	
Scalability of cable systems	
Availability of carrier that can operate a Facebook cable	
Existing commercial relationships telecom operators	

Relined
Governmental regulations
Investment decisions regarding submarine electricity cables
Data demand between Amsterdam and Denmark
Capacity requirements for control systems for windfarms at sea
Latency on a route
Price to add an optic fiber to a submarine electricity cable
Growing data transit demand
Existing backhaul networks

Table 5 shows that the investments in submarine communication cables are dependent on a large number of factors according to the investors. The next step is to extract different groups of factors which explain the investments in submarine communication cables. Similar types of factors such as demographic or legislative factors are clustered to provide an overview which type of issues should be addressed by the research framework.

First of all individual factors of companies such as 'the strategy of British Telecom', 'Capex of the company', 'Existing capacity on a route' and 'Data demand' show that there are large differences between the individual companies. This means that the structure of the market cannot explain the investments completely. There are large differences between the companies and therefore strategies will also differ from each other. For example an ISP such as British Telecom has very different infrastructure needs than the CDN Facebook (TeleGeography, 2017). The individual differences of companies are an important factor. Secondly, regulations have an influence on the investment strategy. Table 5 shows that factors such as 'ESCA/ ICPC/ NASCA recommendation compliance of a country' or 'access to market' have an effect on the investment behavior. Therefore government influence should be taken into account for the election of the theories. The third group of factors that explain the investment behavior is the behavior of co-investors. Table 5 shows these as 'the availability of investment partners' and 'agreement with the consortium'. The fourth group of factors that have an effect on the investment behavior is the geographical group of factors. The geographical location has an effect on other factors such as the 'latency of the cable' and the 'total costs of the system' and the 'Fishing activity'. Although the fishing activity can also can be part of the regulations group of factors. Other relevant factors are 'seabed properties' 'shore characteristics'. These two factors can affect the 'easiness of reaching the shore' and the 'risk of cable cuts'. For example, shallow rocky waters will increase the difficulty to reach the shore and will increase the risks of cable cuts due to higher cable vulnerability. Demographic factors such as 'number of inhabitants of a country' and 'the economic and financial importance of a region' also play a role. Summarizing, there are five groups of factors identified, which are; individual company preferences, government regulations, behavior of co-investors, geographical factors and demographic factors.

3.4 Selection of the economic theories

Now that the factors have been identified that need to be addressed by the theories, the selection of the economic theories can start. First, based on the previous paragraph, the theories used in the framework of de Vaan (2012) are discussed in terms of their power to explain the investment behaviour of submarine communication cables. If this is the case they will be selected for further research. These first theories are the Porter's five forces theory (Porter, 1979), Transaction cost economics (Williamson, 1998) and Resource-based view (Barney, 1991) which are evaluated respectively in subparagraph 3.4.1, 3.4.2 and 3.4.3. In paragraph 3.4.5 and 3.4.6 two additional theories are discussed which are transaction cost regulation (Spiller, 2013) and multi-sided platform-markets (Rochet and Tirole, 2003). For every theory the relevancy is discussed based on the factors from the interviews and the underlying conditions and assumptions.

3.4.1 Porter's five forces theory

The first theory that will be discussed is Porter's five forces theory. (Porter, 1979) Porter argues that: "the state of competition in an industry depends on five basic forces… the collective strength of these forces determines the ultimate profit potential of an industry" (Porter, 1979). Figure 8 visualizes the forces that shape industry. These forces are; the threat of new entrants, threat of substitute of substitute products or services, bargaining power of suppliers, bargaining power of customers and competition with current competitors. Below the different forces are discussed in more detail as discussed by Porter;

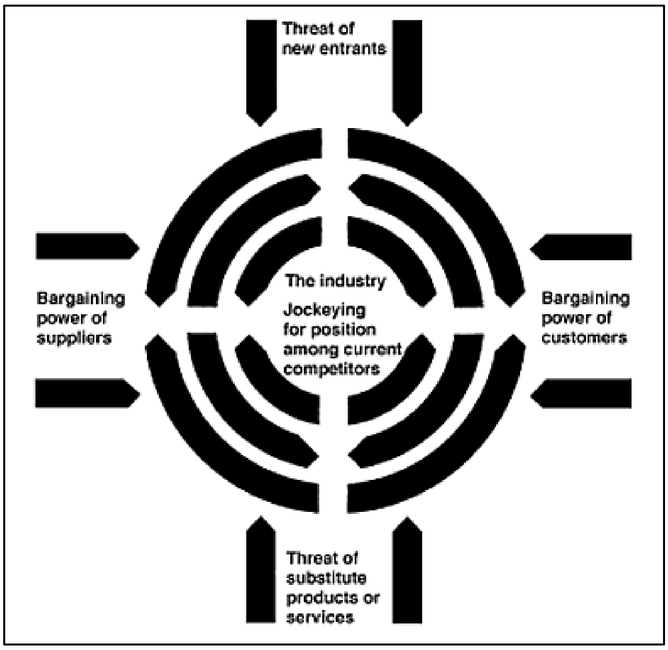


Figure 8 - Forces governing competition in an industry (Porter, 1979)

Threat of new entrants: "The first force that determines the positioning of companies in the industry is the threat of new entrants. New entrants are likely to bring new capacity, desire to gain market share and substantial resources. Therefore they pose a threat to the existing market players". (Porter, 1979).

Bargaining power of suppliers: The second force is the bargaining power of suppliers. "Suppliers can exert bargaining power on participant in an industry by raising prices or reducing the quality of purchased goods and services" (Porter, 1979).

Bargaining power of buyers: The bargaining power of buyers or consumers is the third force of the five forces model. "Buyers have large bargaining power and are expected to bargain when; purchases are made in large volumes, the products are highly standardized, the buyer earns low profits or the buyers pose a credible threat of integrating backward to make the industry's product" (Porter, 1979).

Substitute products: "By placing a ceiling on prices it can charge, substitute products or services limit the potential of an industry. Unless it can upgrade the quality of the product or differentiate it somehow (as via marketing), the industry will suffer in earnings and possibly in growth" (Porter, 1979).

Jockeying for position among current competitors: The fifth and last force is the 'jockeying for position among current competitors. The first four forces describe external forces that originate outside the industry or from different levels in the value chain. Jockeying for position is a force that originates within the industry and describes the effect of competition amongst direct competitors. Porter describes that intense rivalry is related to the presence of a number of factors. These factors are: "high number of competitors or are roughly equal in size and power, industry growth is slow, fixed costs are, capacity is normally augmented in large increments, exit barriers are high and the rivals are diverse in strategies, origins and "personalities." They have different ideas about how to compete and continually run head-on into each other in the process". (Porter, 1979).

Assumptions of Porter's five forces theory

Based on (Porter, 1979) and (Barney, 1991) the following assumptions are identified for Porter's five forces theory:

- Methodological Holism
- The strategy of a company depends on the market structure
- Companies have comparable resources and assets

Relevancy of the theory

Porter's five forces theory can be used to understand the behavior of firms in an industry. However the theory is not suitable to analyze the investments in submarine communication cables. The assumption that companies have comparable resources and assets and that the strategy of a company is solely based on the structure of the market is not true for the submarine communication industry. As discussed in paragraph 3.3.3 there are large differences in investment behavior between an ISP such as Verizon and a CDN such a Facebook. Chapter two also showed that ISPs and CDN are different types of companies in the interconnection market. Therefore the assumption that the market structure only will explain the investment behavior is not feasible. Also between ISPs there are large differences in network assets and products. A second argument against the use of Porter's five forces theory is the existence of government interference and network effects in the submarine telecom infrastructure industry. The theory fails to explain these factors since it assumes that companies have comparable resources and assets and methodological holism. Therefore Porter's five forces theories is considered to be not sufficiently relevant to explain the investments in submarine communication cables.

3.4.2 Transaction cost economics

The transaction cost economics is the product of two fields of economic research which are the 'New Institutional Economics' and the 'New Economics of Organization' (Williamson, 1998). First a short introduction is provided of the New Institutional Economics theory. After that the transaction cost economics is explained, which is embedded in the New Institutional Economics.

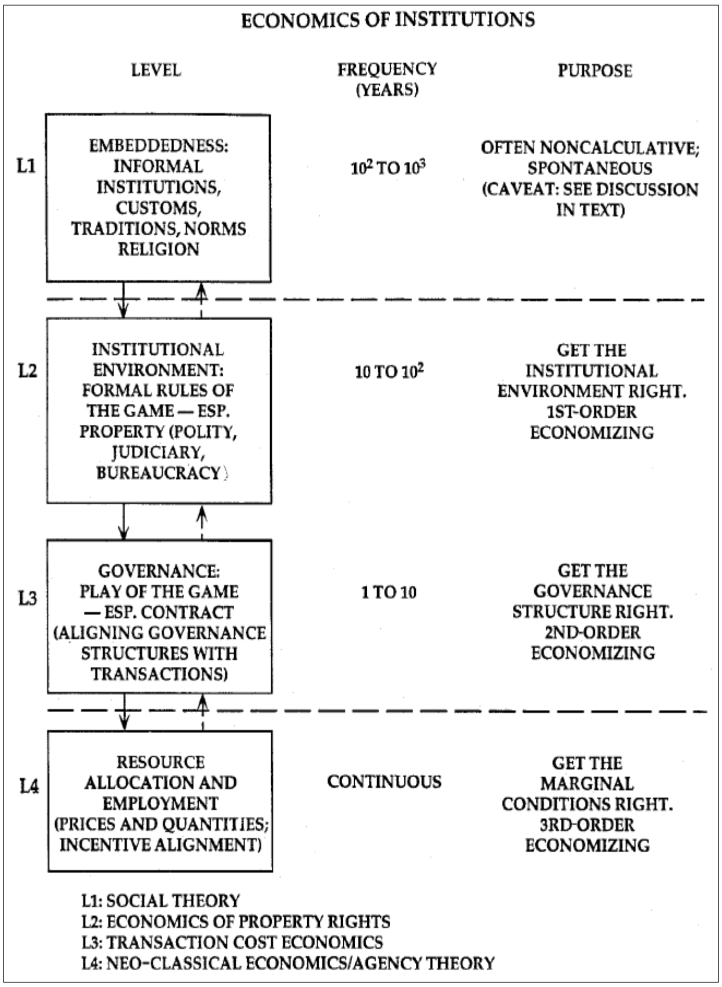


Figure 9 - Framework Economics of Institutions (Williamson, 1998 p. 26)

"New institutional economics deals with two parts. 'Part one deals with the institutional environment – the rules of the game – and traces its origins to Ronald Coase's 1960 paper on 'The Problem of Social Cost.' Part two deals with the institutions of governance – the play of the game – and originates with Coase's 1937 paper on 'The Nature of the Firm" (Williamson, 1998, p. 24). Williamson distinguished four levels of social analysis. These different levels are displayed in figure 9. The New institutional economics focuses mostly on level two and three of the framework, the institutional environment which are 'the rules of the game' and the governance which is 'the play of the game'.

Transaction cost theory is part of the third level in the framework, which deals with the play of the game. It takes level two, the rules of the game, as shift parameters and analyses the transaction costs that are made by looking at the contracts. The theory assumes that: "all complex contracts are unavoidably incomplete. Also, transaction opportunism, whereupon additional contractual complications are posed. Not only does an incomplete contract contain gaps, errors, and omissions (by reason of bounded rationality), but mere promise, unsupported by credible commitments, is not self-enforcing by reason of opportunism." (Williamson, 1998, p. 31). The theory is helpful because it can attenuate the ex-post hazards of opportunism through the ex-ante choice of governance. Safeguards can be implemented to avoid opportunism by the actors that create transaction costs. The transaction costs are mostly described by three dimensions which are frequency with which the transaction recur, the uncertainty to which they are subject and the condition of asset specificity (Williamson, 1998).

Assumptions of the Transaction cost theory

Based on the (Williamson, 1998), (Williamson, 1979) and (Williamson, 1989) the following assumptions were identified:

- Methodological individualism
- Opportunism
- Asset specificity
- Contractual incompleteness
- Bounded rationality

Relevancy of the theory

The transaction cost theory is relevant to analyze the investment behavior of submarine communication cable industry. Unlike Porter's five forces theory the transaction cost theory assumes methodological individualism. Paragraph 3.3.3 shows this is important since the large differences between the companies that invest in submarine communication cables. Furthermore the submarine communication infrastructure industry is likely to have high asset specificity. Paragraph 3.3.3 showed that geographical factors such as location and other geographical properties play a role. Furthermore the transaction cost economic theory can also explain the co-investment and consortia in which the investors are involved, because of its methodological individualism assumption and the contractual incompleteness assumption. By assuming that individual contracts between CAPs and telecom providers are incomplete, the effects of different types of contracting can be analyzed. In this way the transaction cost theory can explain the level of vertical integration and the formation of consortia. What type of governance structure is aligned with the transaction characteristics of submarine cables? Among others Klein (2014) and others acknowledge the usefulness of transaction cost economics to explain and predict vertical integration. Therefore the transaction cost economic theory is regarded as useful. The theory can explain the effect of individual differences between companies, the existence of co-investors and the effect of geographical factors.

Operationalization of the transaction cost economics

Figure 10 shows the operationalization of the transaction cost economics. Different types of governance structures of content and application providers discussed based on the transaction characteristics for submarine communication cable products. The relative level of transaction costs of every governance structure helps to understand the investments behavior.

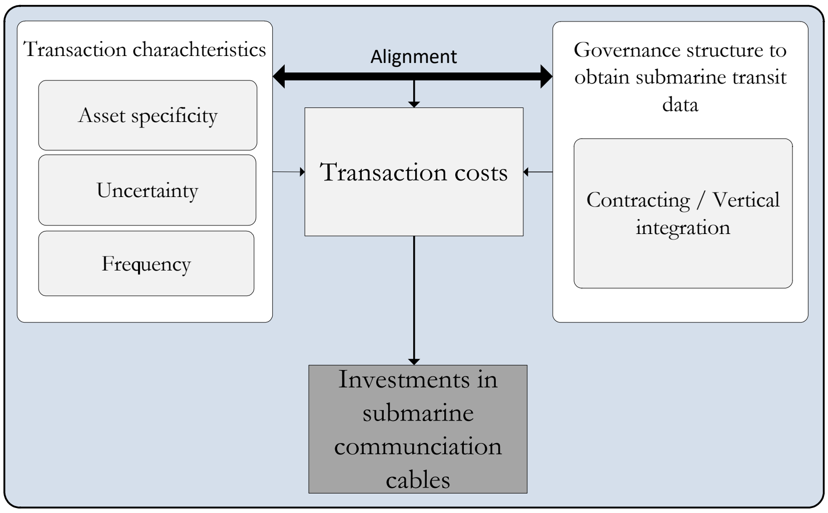


Figure 10 - Operationalization of transaction cost economics

3.4.3 Resource based view

Resource based view is a method to analyse the strategies of individual firms. The resource based view was developed as an alternative for theories such as the Five Forces theory of Porter. Porter's theory assumes that the resources of firms are homogenously distributed. Therefore it is not possible to create a competitive advantage with help of the own resources. Instead, theories as the five forces theory analyse the environment to explain competitive advantage. On the contrary, Barney (1991) argues that the competitive advantage and even sustainable competitive advantage can be achieved by a firm. An assumption of the Resource-based view is that the strategic resources of firms are not heterogeneously distributed over the firms. The theory also assumes that some resources are not mobile across firms. Barney defines strategic firm resources as: "all assets, capabilities, organisational processes, firm attributes, information and knowledge that is controlled by a firm that enables the firm to improve its efficiency and effectiveness" (Barney, 1991, p. 101). If these strategic firm attributes are rare, imperfectly imitable, valuable and not substitutable they can create a sustainable competitive advantage for a firm. Figure 10 provides an overview of the Resource based view.

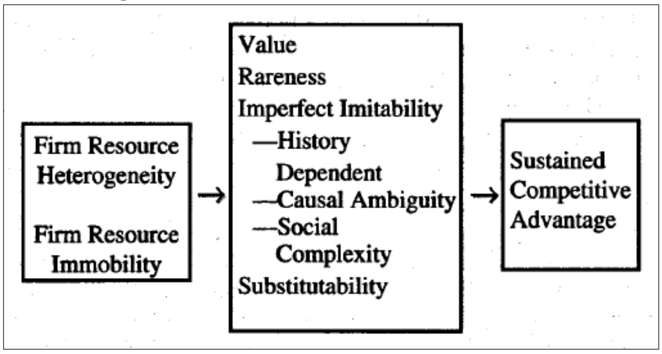


Figure 11 - The relationship between resource heterogeneity and immobility, value, rareness, imperfect imibility, and substitutability, and sustained competitive advantage

<u>Assumptions of the Resource-based view</u>

Based on (Barney, 1991) the following assumptions of the resource-based view are:

- Methodological individualism
- Firm resources are distributed heterogeneously
- Firm resources can be immobile

Relevancy of the theory

The Resource based view is a theory that is relevant to explain the investment behaviour in submarine communication cables of individual firms. Paragraph 3.3.3 shows that the individual strategies and assets of companies have an effect on the investment behaviour. This fits nicely with the methodological individualism assumption and asset heterogeneity assumption of the resource-based view theory. Companies that invest in submarine communication cables have different types of resources. Chapter two showed that both ISPs and CDNs invest in submarine communication cables. The different types organizations are expected to have different types of assets. The effect of the different resources of companies on the investments in new cables can be explained by this theory. Appendices P, Q, R and S are examples of the large variety in networks of different investors in submarine communication cables.

Operationalization of the transaction cost economics

The resource based theory is operationalized as in figure 12. The different firm assets are analysed for the interviewed ISPs, CDNs and government organization. In this way the different strategies regarding investments in submarine communication cables can be explained based on the strategic firm attributes. In other words the existence of different firm resources creates different capabilities, behaviour and strategies. This can be used to explain the investments in submarine communication cables on an individual level of these different firms

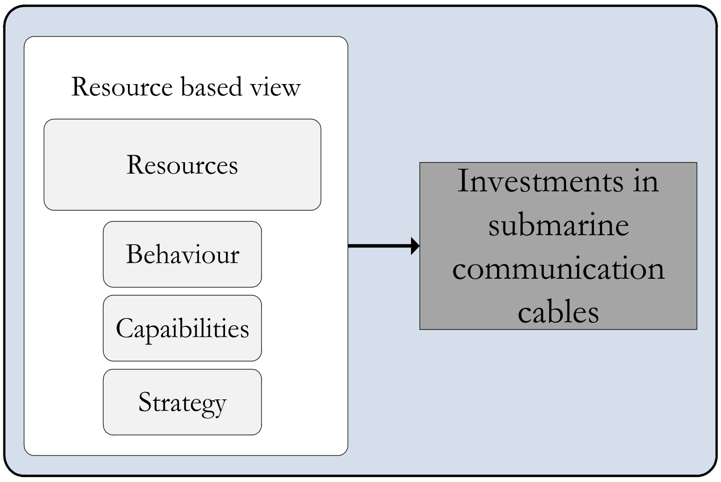


Figure 12 - Applying the Resource based view to analyze the investments in submarine communication cables

3.4.4 Discussion of first the selection process

Paragraph 3.4.1, 3.4.2 and 3.4.3 discussed the relevancy of the theories that were used in the framework of de Vaan (2012). The paragraphs discussed Porter's five forces theory, Transaction cost theory and Resource based view. Porter's five forces theory will not be used in the analysis. As shown in paragraph 3.4.1 this theory is not suitable to analyse investment behaviour of companies in submarine communication cables. The theory cannot be applied to a network industry with government interference. Also the individual network assets and characteristics of the interconnectivity market cannot be explained sufficiently due to its methodological holism assumption. The resource-based view is a relevant theory as shown in 3.4.2. This theory can explain the differences in the underlying business cases of companies that invest in submarine cables based on the differences in resources. The transaction cost theory is discussed in 3.4.3. This theory is relevant to explain the co-investment and the vertical integration in the industry.

Paragraph 3.3.3 showed that five groups of factors are important to explain the investment behavior in submarine cables. These five groups are; individual company preferences, behavior of co-investors, geographical factors, demographic factors and government regulations. The effects of the first four of the groups of factors can be explained by the transaction cost theory and the resource-based view. However the effect of government regulations cannot yet be explained by any of these theories. Since this thesis also aims to understand the policy options for governments another theory has to be added. The theory that should be added has to explain the effects of government regulations on the investment behavior of firms. In the next two sub-paragraphs respectively the transaction cost regulation theory and the multi-sided platform-markets theory are discussed.

3.4.5 Transaction cost regulation

Transaction cost regulation is a framework that was developed by Pablo T. Spiller. According to Spiller: "Transaction cost regulation (TCR) consists of the study of the governance features of the interaction between governments and investors fundamentally,[1] but not exclusively, in utilities sectors. As in standard transaction cost economics, the nature of contracting hazards is what determines the fundamental features of the governance of these interactions (e.g., Williamson, 1979). Regulation, and regulatory contracts, the forms that take the governance of such interactions, are then to be understood as coming to grips with the inherent hazards of these interactions. Emphasizing regulation as the governance structure of these interactions, and understanding the organizational impact of their inherent contractual hazards, differentiates TCR from other approaches to regulation. In particular, the emphasis on contractual hazards requires assessing real behaviour, by real people in real environments within real institutions" (Spiller, 2013, p. 232). The framework helps to understand the contractual hazards between governments and investors. In this way the framework creates understanding how government regulation and interaction between the users of the sea and the government can influence the investment behaviour of investors in submarine cables. According to the framework opportunism is possible if utility-investors are regulated by a government. This can be either governmental opportunism or third party opportunism. "Governmental opportunism consists of the ability of governments to change the rules of the game via the standard use governmental powers to extract the quasi-rents of utility investors" (Spiller, 2013, p. 234). Third party opportunism is when the investors can behave opportunistically in regard to the regulator, if for example information asymmetry exists between the regulator and the investor. Whether governmental/third party opportunism will arise depends on two determinants, which are the type of investments and 'positive political theory'. In other words the political institutional environment also affects the risks for opportunism. Large sunk costs make investors more susceptible for governmental opportunism, since the investors will be willing to continue operating as long as operating revenues exceed operating costs (Spiller, 2013). Opportunism and regulations will have an effect on the performance on the investment behaviour of investors in submarine communication markets.

Assumptions of the Transaction cost regulation framework

The transaction cost regulation framework is based on transaction cost economics (Spiller, 2013). There the transaction cost regulation framework has the same assumptions as the transaction cost economics (Williamson, 1979). These assumptions are:

- Methodological individualism
- Governmental/Third party opportunism
- Asset specificity
- Contractual incompleteness
- Bounded rationality

Relevancy of the theory

The transaction theory is relevant to explain the investments in submarine communication cables. The effect of governmental regulations of a country on the investments behaviour of companies is relevant. Table 5 and 3.3.3 show that governmental regulations have an effect on the investment behaviour of firms. The only problem is that the framework is mostly used to analyse utilities. Spiller describes utilities as sectors with three fundamental features. The "first one is that products are consumed widely. The second condition is that utilities exhibit important economies of scale and scope at the relevant levels of demand. The last condition is that investments are characterized by a high level physical specificity (i.e. have a high component of sunk investments)" (Spiller, 2013, p. 234). Although one could argue that submarine communication cable networks meet all these three conditions the submarine communication industry is typically not seen as a utility industry. Most of the feature of utilities are true to a certain extend for the submarine communication industry. Therefore it is assumed to be applicable for this study.

Operationalization of the transaction cost regulation framework

Figure 13 shows how the Transaction Cost regulation theory is applied to understand the effect of governmental regulations on the investments in submarine communication cables to a country. The existence of governmental opportunism and third party opportunism in a country will be first identified. Any governmental opportunism or third party opportunism has an effect on the relationship between the government and the investors. Higher transaction cost of the regulations ultimately can lead to lower investments. (Spiller, 2013) In this case opportunism can reduce the investments in submarine communication cables to a country. In chapter 6 the transaction cost theory is specifically applied to the effects government regulations in the Netherlands and Spain on the investments in submarine communication cables to this country.

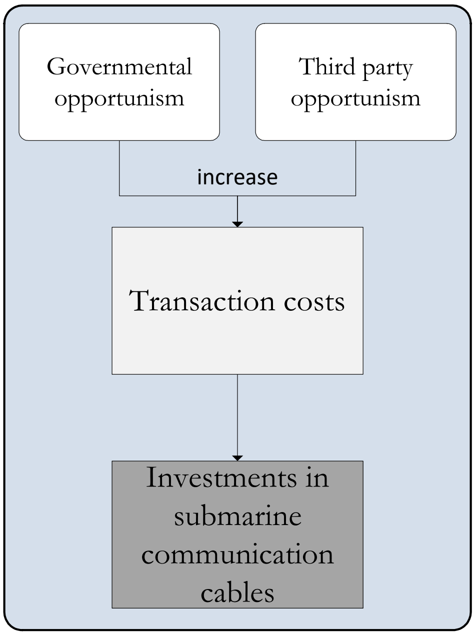


Figure 13 - Application of the Transaction Cost Regulation theory to understand the effects to the investments to a country

3.4.5 Multi-sided platform markets theory

The multi-sided platform markets theory explains the business case for platform companies. According to Rochet and Tirole (2003): "there is an opportunity for a platform to increase social surplus when three necessary conditions are true: there are distinct groups of customers, a member of one group benefits from having his demand coordinated with one or more members of another group and an intermediary can facilitate that coordination more efficiently than bi-lateral relationships between the members of the group. If these three conditions are met a platform market can exist which takes advantages of the positive network externalities" The multi-sided platforms can be divided into three categories, which are the market-makers, audience-makers and demand coordinators. This lists however is not exhaustive (Evans, 2003).

Assumptions of the multi-sided platform market theory

Based on (Rochet & Tirole, 2003) the assumptions of the multi-sided platform market theory are:

- Methodological individualism
- The coordination of demand between groups can increase social surplus
- Intermediation can be more efficient than bi-lateral relationships

Relevancy of the theory

Theory about multi-sided platform markets it is not regarded as relevant although it could be used since it assumes also methodological individualism. Theory only explains the business cases of the platform firms and not the investments in the cables itself. Furthermore the multi-sided platform market theory it is not applicable the other types of companies. This really limits the use of the theory. The resource-based can be applied to understand the business cases of all types of companies. Therefore the resource-based view theory is preferred over the multi-sided platform market theory.

3.5 Constructing the research framework

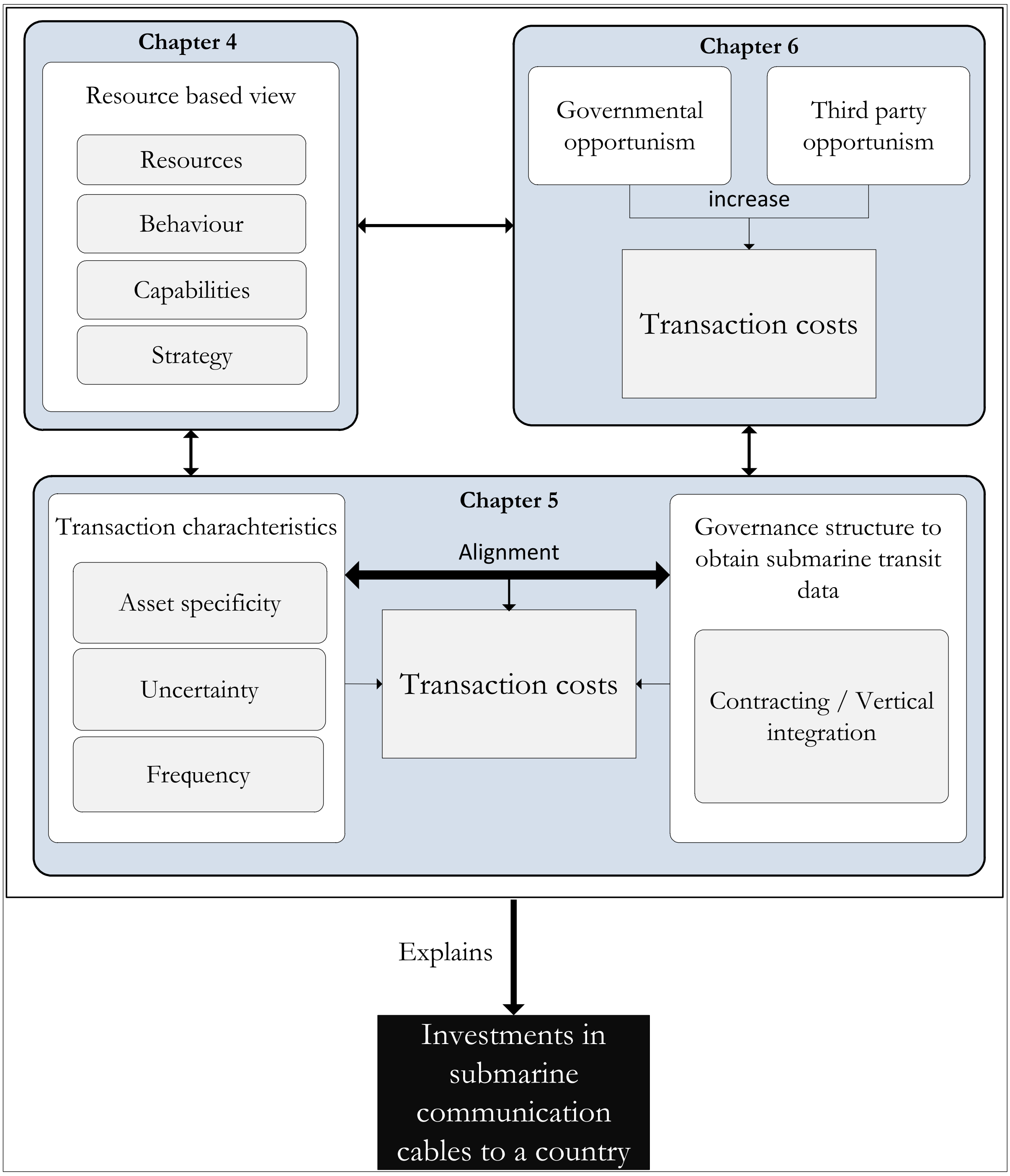


Figure 14 - Operationalized research framework of this study

In figure 14 the complete operationalized research framework is displayed. In chapter 4 the individual resources of companies that invest in submarine communication cables are analysed. This gains insight in the resources, behaviour, capabilities and strategies of these different companies. In this way the resource based view provides insight in the behaviour of the firms.

Then in Chapter 5 the transaction cost theory is applied to analyse the firms. The transaction cost theory explains the investments in submarine communication cable by evaluating the alignment between the transaction characteristics and the governance structures between content and application providers and telecom operators. Content and application providers want to align the transaction characteristics with the governance structure for transit to minimize the reduction costs. In this way the behaviour of investors can be understood. Chapter 6 analyses the influence of regulations of a country on the investments in submarine communication cables.

In the end of every chapter factors are identified which explain the investment behaviour of companies based on the theory. The factors for the comparative case study which are formulated in chapter 4,5 and 6 are placed into a table. This list of factors is used in a comparative case study between the Netherlands and Spain which helps to validate and evaluate the explanatory framework.

3.6 Scientific reflection of the selection of the theories

This chapter aimed to develop a research framework to understand the investments in submarine communication cables. The framework of de Vaan (2012) was used as a starting point. This framework combines different theories in one framework to create a pluralistic theory of the firm. According to Groenewegen & Vromen (1996): "…formulating an all-embracing, all-condition theory is infeasible. The principal reason is that any of these theories is applicable under different conditions. If some theories can be assumed to be applicable under different conditions, they can be said to be complementary. In combination these theories then can be said to give us a rich understanding of some set op phenomena. Such theories can also be seen as complementary rather than conflicting or supplementary". In the framework of de Vaan three theories are combined, namely resource-based view, transaction cost theory and Porter's five forces theory.

The assumption is that a pluralistic framework can be constructed with different theories which can be used to analyse one research topic. However the combination of theories which explain the same issues under different assumption can create conflicts between those theories. In this case it is not expected that there are conflicts since all three theories assume methodological individualism. On the contrary the different theories can increase understanding because they allow analysing the same problem with different perspectives. The economies theories in the research framework were chosen based on the relevant factors. These factors were extracted from the interviews with investors that have investments to the Netherlands and Spain. In these interviews the factors were identified which effect the investment behaviour of companies. The outcomes of the interviews were contrasted with the resource-based view, transaction cost theory and Porter's five forces theory. Porter's five forces theory has the assumption that the market structures explain the investment behaviour. Also it assumes holism. From the interviews it was clear that this assumption was not feasible, since the behaviour of companies is dependent on their existing infrastructure. The other two theories, resource-based view and transaction cost theory have an individualistic methodology. Individual differences between companies create differences in behaviour. (Barney, 1991; Williamson, 1998). Both theories were accepted for the framework as explained because they explain different parts of the 'scientific puzzle' and are supplementary to each other. The resource-based view provides insight in the business case of different types of companies that invest in submarine cables. The transaction cost theories can help to create additional understanding about the investments of content and application providers as part of the vertical integration. However interviewees indicate that the legislation in a country also is important factor to explain the investment behaviour of a firm. Therefore the transaction cost regulation framework was added, which helps to understand the effect of legislation in a country on the firm behaviour. Because the transaction cost regulation framework is based on the transaction cost economics it shares the assumptions. Therefore it fits in the framework.

Chapter 4: Analysis from a resource-based view

This is the first analysis chapter which has the goal to understand the investment behavior of different types of investors based on their resources. The resource-based view is used to analyze the resources of telecom providers, CAPs and a public enterprise. In this way the aim is to understand what the incentives are for these firms are to invest and what the differences are between the investors.

4.1 Structure of the chapter

In 4.2 an introduction of the resource-based view is provided. It also provides an overview of the application of the theory. After that in 4.3 the resource-based view is applied to the interviewed telecom providers. Based on the interviews with the telecom providers and the industry information the investment strategies of telecom carriers are explained. After that in 4.4 the resource-based view is used to analyse the content and application providers. Interviews with Facebook and Microsoft together with sector information are combined to understand the investment strategies of CAPs. In 4.5 the strategy of Relined, a public enterprise in the Netherlands is analysed. This is also done with the resource-based view. Subsequently in 4.6, the conclusion, a comparison is made which discusses the differences between the investors in investment motives and strategy. Based on these outcomes factors are formulated which influence the investment behaviour of the different types of firm. These factors are the input for the explanatory model in chapter 7 and are formulated in 4.7. Lastly in 4.8 a reflection is provided of application the resource-based view to this research problem.

4.2 How to apply the theory?

The resource-based view is a theory that helps to understand how a firm can create a sustainable competitive advantage over other firms. According to the resource-based view four conditions for the resources of a firm have to be met to sustain a sustainable competitive advantage (Barney, 1991). A firm has to have resources that are valuable, rare, imperfectly imitable and not substitutable. The imperfectly imitability of resources can be caused by unique historical conditions, causal ambiguity or social complexity. These imperfectly imitable resources can help to explain competitive advantage and therefore will help us to understand the investment decisions of submarine communication cable owners. There are four different types of resources that can cause a sustainable competitive advantage; these are physical, capital, human capital and organizational resources. (Barney, 1991). Table 6 shows the firm resources that are analyzed in this thesis. For the physical resources it was chosen to describe the backhaul infrastructure since submarine communication cables is part of this infrastructure. Furthermore table 5 shows that investors such as Verizon and British Telecom say that their current backhaul infrastructure influences future investments.

Table 6 - Firm Resources of Submarine Investors that are investigated

Physical Resources:	Backhaul infrastructure
Capital:	Revenue CAPEX
Human Capital Resources:	Experience in the submarine industry
Organizational Resources:	Type of data services offered Participation in consortia

The second firm resources that are investigated are the capital resources of the firms. These consist of the total yearly revenue and the Capital Expenditure (CAPEX) of a firm. New submarine communication cable requires large investments. For this reason it is interesting to compare the capital resources of companies. The third analyzed resources are the human capital resources of the firm. The human capital resources that will be discussed are the differences in experience in the submarine industry of employees. According to Mrs. Violari of Facebook the experience of employees is one reason why Facebook co-invests with other telecom providers. Therefore it is relevant to compare this specific resource of human capital. From the organizational resources two types of resources are party of the analysis. These are the type of data services that can be offered by a firm and the participation in consortia. These two organizational resources were also chosen based on table 5. Together the firm resources provide a basis to understand the individual investing strategies of investors. Furthermore it also might provide insight in the differences in investing behavior between telecom operators, content and application providers and public actors.

4.3 Resource based view applied to Telecom providers

The four telecom operators that are part of the analysis in this paragraph are KPN, British Telecom, Verizon and Telefónica. The different resources are discussed below:

4.3.1 Physical resources: Backhaul infrastructure

Below the most backhaul infrastructure of the four companies are discussed:

- **British Telecom:** "The most important part of the transit network of British Telecom is their 'Pan-European network" (G. Rea, 2017). This network of terrestrial and submarine backhaul connections includes two cables between the United Kingdom and the Netherlands which are key links in the network (G. Rea, 2017). BT also operates connections between the United Kingdom and the European continent through the channel tunnel. (G. Rea, 2017). Furthermore BT owns partly trans-Atlantic cables to the USA such as the TAT12 and TAT14 (Telegraphy, 2018). The total amount of cables it is involved with and the total reach of the network are displayed in appendix M.
- **KPN:** Owns a pan European and a North-American terrestrial backhaul network (KPN, 2018) Furthermore the KPN is involved with a large number of submarine cable projects,

which are part of their global network, which is displayed in appendix N. This network connects Europe, the American continent and parts of Africa and Asia. KPN also operates a part of a submarine communication cable system, which is the TAT14. This trans-Atlantic cable lands in the Netherlands (Dinkelman, 2017).

- **Telefónica/Telxius - Telxius** owns terrestrial backhaul networks in the Europe and the USA, as displayed in Appendix O. The network of Telefónica does not have a clomplete global reach. Instead their network is focused on connections between Europe, North America, Central America and South America. Telxius also is involved in submarine cables that connect Europe with African countries. Telxius was the first European Telecom Provider that co-invested in a submarine cable with content and application providers. Together with Microsoft and Facebook they co-invested in the MAREA-cable which connects the United States with the North of Spain (Microsoft, 2017). Telxius is the operator of this cable system.
- **Verizon:** Appendix P shows the very extensive global network of Verizon. Verizon owns (partly) a global backhaul network including submarine cables network systems that connect the six contents through a large number of cables (Booi, de, 2017) Appendix P also shows the European, Asia and North American terrestrial networks of Verizon. Most of the data centers are located in the United States. (Verizon, 2018)

The backhaul networks of the telecom providers in this analysis have very similar structures, as displayed in appendices M to O. According to Mr. de Booi, Verizon aims to 'connect the large economic centers in the world'. The other telecom operators seem to have the same investment strategy to connect places around the world which have the large transit data demand. British Telecom, KPN and Verizon have investments in cables around the world and try to have a network reach which is as large as possible. Telefonica lacks backhaul infrastructure in Asia. Instead it has a more extensive network in Latin America. Therefore there are small variations between the telecom providers. The submarine communication cables in the networks of the telecom providers are usually not completely owned by the network operator. Most of the cables were constructed by large consortia (TeleGeography, 2017).

4.3.2 Capital resources: Revenue and CAPEX

Table 7 provides an overview of the revenues and the capital expenditure of British Telecom, KPN, Telefónica and Verizon. It is important to mention that the listed revenues and the CAPEX are not only obtained with the sales of service on the transit network. Telecom operators such as Verizon provide besides interconnectivity also other types of services, such as broadband and mobile phone services in different countries (Verizon, 2018). In the paragraph 4.3.1 it became clear that Verizon has the largest network. Therefore it is expected that Verizon has the largest revenue and CAPEX in comparison with the other three telecom operators.

Table 7 - Revenue and CAPEX of telecom operators (in millions) in 2016-2017

British Telecom (British Telecom, 2017)	**Revenue:** **CAPEX:**	**€27,105** **€3,887**
KPN (KPN, 2018)	Revenue: CAPEX:	€6,780 €1,193
Telefónica (Telefónica, 2017)	Revenue: CAPEX:	€52,036 €8,928
Verizon (Verizon, 2017)	Revenue: CAPEX:	€102,376 €14,013

Verizon has indeed the largest revenue of all the telecom providers. The revenue of Verizon is nearly two times as large as the revenue of Telefónica, the second largest telecom operator in table 7. In general it is possible to say that there are large differences between the revenues of the different telecom operators and the corresponding CAPEX. For smaller telecom operators such as KPN and British Telecom it is likely to much riskier to invest in expensive new submarine communication systems. Large telecom operators have more investing opportunities to invest in new submarine communication systems due to the higher CAPEX.

4.3.3 Human capital resources: Experience in the submarine industry

The level of human capital resources is described by discussing the experience of the company in the submarine industry. Below an overview is provided of the different levels of experience of the companies.

- **British Telecom:** According to Mr. Rea from British Telecom the United Kingdom has traditionally has been a natural hub for trans-Atlantic telecommunication cables. The former incumbent British Telecom is expected to have ample experience in the submarine industry in construction, maintenance and exploitation. British Telecom has operates a number of submarine communication cables by itself such as the 'Farland North' between the United Kingdom and the Netherlands.
- **KPN:** KPN is the former incumbent of the Netherlands and partly owns and operates part of submarine communication cables for a relative long time. A part of the route of the TAT14 is operated by KPN (Knol & Dinkelman, 2017). Therefore KPN has experience in the industry and knows how to operate submarine communication cables.
- **Telefónica/Telxius:** Telefónica has large number of submarine communication cables. Recently Telefonica created a separated entity for the management of the backhaul networks, which is called Telxius. According to Mr. Moreno Rebollo of Telefónica, Telxius showed the market that it is a reliable and experienced partner by doing the MAREA cable project with Microsoft and Facebook. Therefore it can be said that Telxius is an experienced in the industry.
- **Verizon:** Verizon has one of the largest global backhaul networks in the industry with a large number of submarine cable systems, as shown in appendix P. Therefore it can be said

that Verizon is one of the most experienced companies in the submarine communication industry worldwide.

All four of the telecom operators have experience in the submarine communication cable industry and can operate a submarine communication system. Therefore there are no large differences between the telecom providers in terms of experience in the submarine communication cable industry. However there can be differences with the CAPs and the public enterprise. These are discussed in 4.4 and 4.5.

4.3.4 Organizational resources: Data services and consortia

Below the organizational resources of the four telecom operators are listed. These are the data services that can be provided by the companies and the participation in consortia for the investments in submarine communication cables. More specific the data services of a firm are listed which are directly related with the submarine cables.

The data services that can be provided are:

- **British Telecom:** provides specific data services such as; cloud services and dynamic network services to financial institutions and companies (British Telecom, 2017)
- **KPN:** provides a large number of services such as VPN, Wavelength, International Private Line, IP-transit to companies and institutions. (KPN, 2018; Dinkelman, 2017)
- **Telefónica/Telxius:** provides a large number of services over their cable. Examples of the services are Over-The-Top services (OTT), spectrum, and flexible bandwidth services. (Telefonica, 2017)
- **Verizon:** Data services consist for a small part of the lease of dark fiber. Most of the data services that are Verizon sells are private-IP and Optical Transport Network (OTN) interfaces. An example of an OTN interfaces are for example End-to-end encrypted services (Booi. de, 2017)

The participation in consortia:

- **British Telecom:** participates in large number of mostly large consortia with over ten participatns such as the TAT14 project (G. Rea, 2017; TeleGeography, 2017).
- **KPN:** participates in large number of mostly large consortia. (TeleGeography, 2017)
- **Telefónica/Telxius:** participates in large number of mostly large consortia but also recently invested in the MAREA cable with only Facebook and Microsoft (TeleGeography, 2017; Microsoft, 2017)
- **Verizon:** participates in large number of consortia. (TeleGeography, 2017).

The list above shows that all the telecom operators provide a large number of different data services. According to the colleague of Mr. Moreno Rebollo from Telefonica this has to do with the large sunk costs of a new submarine communication cables. For example the MAREA cable created very high sunk costs for Telxius. This is why 'you cannot be conservative' with the type of data services you provide, in other words 'you have to make the cable profitable' (Moreno Rebollo, 2017). The analyzed telecom providers offer a large number of different services over the submarine communication cable to make the investment profitable. According to Mr. de Booi of Verizon, the focus of their company is to sell private-IP and OTN interfaces with special conditions such as encryption or cloud products. These types of data services heave a higher value in comparison with large volumes data traffic services, which have very low margins. Mr. de Booi argues that the business model of sales of large volumes of data is not profitable. 'In the past Level 3, a transit provider' has bought submarine communication cables for a low price. They hoped to sell data for a very competitive price. Level 3 and GlobalCrossing also constructed a trans-Atlantic cable by itself. However GlobalCrossing went bankrupted because of this investment.' (Booi. de, 2017) However it is unlikely that this investment was the only reason for the bankruptcy. GlobalCrossing also anticipated on higher data transit worldwide. Another reason was that: "Global Crossing was betting that the big telecommunications companies would not be the only customers for its cable lines. It told Wall Street it also hoped to sell capacity directly to big multination companies such as Coca-Cola Co. or American Express Co. "Much to [Global Crossing's] chagrin, that business is locked up by AT&T and WorldCom," Comack said, "They just couldn't penetrate the retail market." "(The Washington Post, 2002). Another example is: 'the former 'Tyco Global Network' (TGN), they had 4 billion dollar invested in new submarine communication cables. They were sold later for only 130 million dollar to TataCommunications. However, "TataCommunications makes hardly money on that cable" according to Mr. Booi.

The costs and risks of the investments in submarine cables are an explanation why all four telecom providers are involved in consortia. 'Only consortium projects like TAT14 turned out to be financial viable because of the spread of risk. A lot of 'private' cable owners went bankrupt' (Booi de, 2017). The participation in consortia of telecom providers is an important resource for telecom providers to spread risk and make submarine cable investments financially viable.

4.3.5 Investment strategy of telecom providers

In order to achieve a sustainable competitive advantage the telecom providers must have valuable, rare, imperfectly imitable and not substitutable resources. The telecom providers all have their unique backhaul network. This infrastructure combined with specific data transit services can create value for the costumer and possible a competitive advantage. However to understand the investment strategies of the telecom providers the global trends in data demand and data supply have to be understood. This is discussed on the next one and a half page.

<u>Demand for data transit</u>

The Submarine Telecom Industry Report 2016 is the yearly magazine of the submarine fibre industry. The report states that: "The world continues to consume ever increasing amounts of data with bandwidth demand project to almost double every two years in the foreseeable future. This demand – largely driven by a continued shift towards cloud services and the continued explosion of mobile device usage – provides numerous opportunities for the submarine fibre industry. Data centre and cloud service providers continue to post strong earnings reports and grow at a rapid pace, which indicates that this bandwidth demand won't be tapering off any time soon" (SubOptic; Submarine Telecoms Forum, 2016, p. 17). It is clear that the demand for data is growing due to new services. A lot of these services are created by machine to machine data traffic which is underpinned by Moore's law and higher than traditional user facing growth. Machine to machine traffic starts to dominate the global traffic demand and defines the growth curve. This trend is created by "machine-driven-connectedness such as connected vehicles and wearables" (Vusirikala & Kamalov, 2016, p. 14). Mr. de Booi from Verizon is less optimistic about the growing demand. According to him the trends as regionalization of the internet will temper the growth of transit data. (Booi. de, 2017) BEREC confirms this, more information is stored close the end-users with help of CDNs to increase the quality of the services (Body of European Regulators for Electronic Communications, 2012, pp. 49-50)

Developments of the data supply

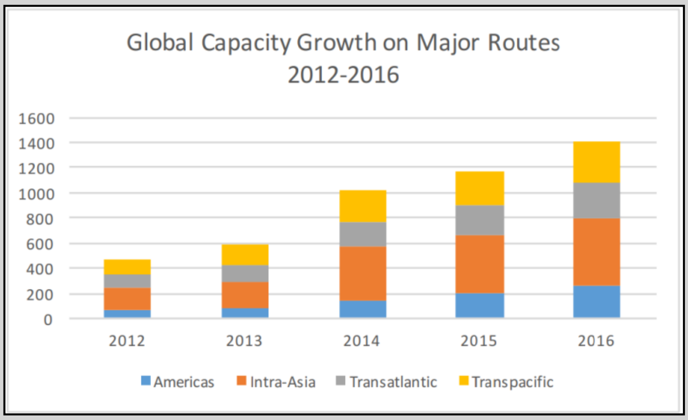


Figure 15 - Global Capacity Growth on Major Routes, 2012-2016 (STF Analytics 2016)

Figure 15 shows that between 2012 and 2016 the global capacity grew about 33% per year. On all three major routes the capacity was growing. "With global demand increasing at a rapid pace, this infrastructure growth rate will not be sustainable for very long, potentially causing demand to far exceed supply" (SubOptic; Submarine Telecoms Forum, 2016, p. 17).

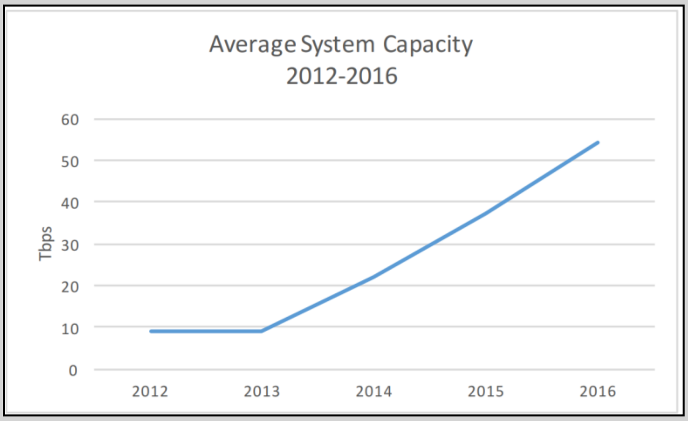


Figure 16 - Average System Capacity 2012-2016 (STF Analytics)

Figure 16 shows that the average system capacity grows steadily in the last years due to upgrading of older systems and new cables. New submarine systems have a much larger capacity then the older cable systems. This means that the technology can meet the strong growing data demand in the future. New cables have much larger capacity because of the technological advancements. For example the new MAREA cable which is completed in the year 2017 has a designed capacity of 160Tbps (Microsoft, 2017). This is well over the average system capacity of roughly 50Tbps in the year 2016. Figure 17 shows the planned capacity for the years 2016, 2017 and 2018 which is also steadily growing. Between 2016 and the end of 2017 the global capacity is estimated to double (SubOptic; Submarine Telecoms Forum, 2016).

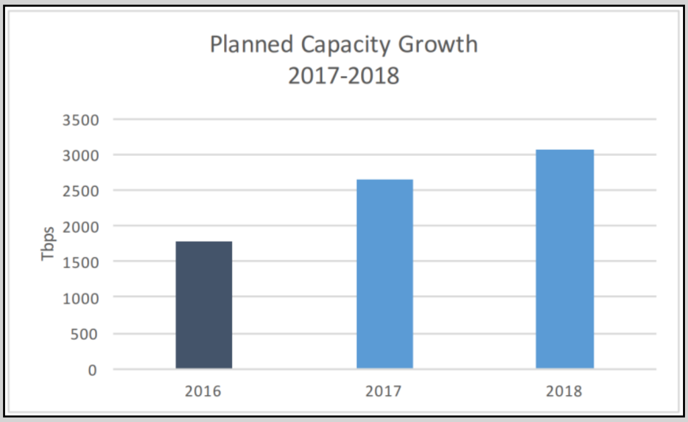


Figure 17 - Planned Capacity Growth (STF Analytics 2016)

Telecom providers might want to invest in new submarine communication cables to take advantage of the increasing data demand. However according to Mr. de Booi telecom operators are reluctant to invest in new (trans-Atlantic connections). "In the end of the nineties there were a lot of investments in submarine capacity between the USA and Europe. In the years 2001/2002 [Dotcom-bubble] the market crashed and it turned out there was an abundance of data capacity available. Up to this day there are very competitive prices and unused capacity between Europe and the USA" (Booi. de, 2017). Sometimes a better option is to upgrade existing submarine communication connections. Mr. Dinkelman of KPN agrees with this view. "Current submarine connections are utilized sufficiently, but there is rest capacity. In case of a lack of capacity, transit capacity can be leased from other carriers. Another possibility is to expand the number of 'colours' that are sent through the cable by raising the number of wavelengths from twenty to eighty.' In this way no large investments have to be made in a new system". However British Telecom and Verizon are still willing to invest in new cables if necessary. If there is clear lack of capacity between on a certain route investment can be made for a new cable (G. Rea, 2017). Most of the new trans-Atlantic communication cables are constructed to connect data centres nowadays (Booi, de, 2017).

4.4 Resource based view applied to content and application providers

The next step is to apply the resource based view to analyze the content and application providers, in specific Facebook and Microsoft. Can we understand their investment behavior based on the analysis of their resources?

4.4.1 Physical resources: Backhaul infrastructure

Below the backhaul networks infrastructures that are owned by the different CAPs which are analyzed are listed. The list provides an overview of these physical resources, including a description:

- **Facebook:** partly owns one trans-Atlantic cable, which is the MAREA cable between Virginia Beach and Bilbao and a trans-pacific cable. Furthermore Facebook partly owns a number of submarine cables that connect different countries in the east of Asia (Economist, 2017). The datacenters of Facebook are located around the world close to the sea. They are displayed in figure 20. In Europe the datacenters are located in the North.
- **Microsoft:** is partly owner of the MAREA cable and the NCP which cross respectively the Atlantic and the Pacific ocean (Teleography, 2018) Furthermore Microsoft co-invested in the Hybernia express of Aquacom, which is nowadays called the GTT express (Crowley, 2017) Microsoft has datacenters all around the world. They are displayed in figure 20.

Since a couple of years the content and application providers started to invest in submarine communication cables. Microsoft and Facebook invest in submarine communication cables to interconnect their own data centres (Crowley, 2017; Violari, 2017). These new cables are 'future proof' according to Mrs. Violari of Facebook. This means that the cable anticipate on the future technical requirements of the Facebook application services. Figure 18 provides a visual display of the active and planned submarine cable systems from content and application providers. The strategy of CAPs is to invest in submarine cables that provide connections between their datacentres which are located close to the cable landing of figure 18.

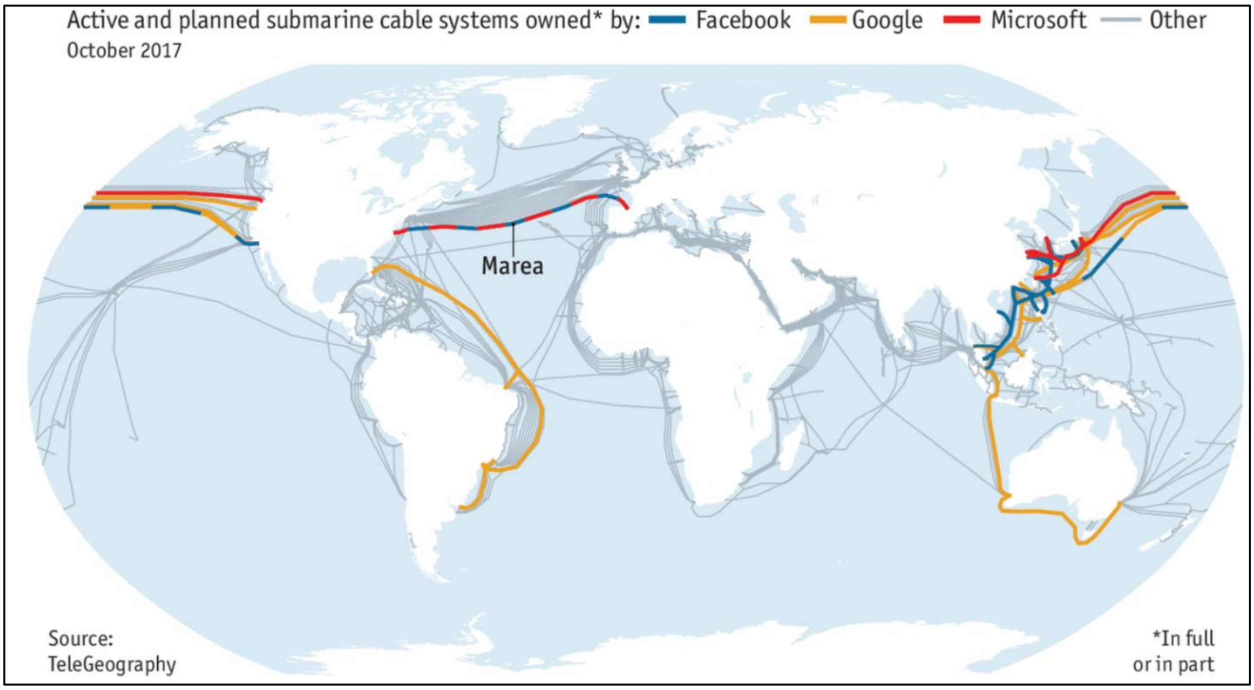


Figure 18 - Active and planned Submarine cable systems of content and application providers (Source: Economist.com)

4.3.2 Capital resources: Revenue and CAPEX

In table 8 provides an overview the revenue and CAPEX of Microsoft and Facebook in the year 2016-2017.

Table 8 - Revenue and CAPEX of content and application providers (in millions) in 2016-2017

Facebook (Facebook, 2017)	**Revenue:** **CAPEX:**	**€22,445** **€3,646**
Microsoft (Microsoft, 2018)	Revenue: CAPEX:	€74,022 €7,230

Microsoft and Facebook are both content and delivery providers. The revenues of these companies are not directly from the sales of telecom infrastructure. The revenue is created by the sales of an application or content and is not directly related to the sales of data transit services.

4.4.3 Human capital resources: Experience in the submarine industry

The level of human capital resources is described by discussing the experience of the content and application providers in the submarine industry. Below the different level of experience in the submarine industry is listed for Facebook and Microsoft.

- **Facebook:** Does not have a lot of experience in the submarine communication industry. The company wants to obtain experience in this field from the established players, such as Telefónica (Violari, 2017) Facebook does not want operate submarine cables by itself.
- **Microsoft:** Until recently Microsoft did not have experience in the submarine fibre industry. First Microsoft started to buy transit data on a large scale and co-invest in submarine communication cables. This helped us to understand the industry (Crowley, 2017) Now with MAREA they took the next step and constructed a cable by itself. (Microsoft, 2017)

Until recently Facebook and Microsoft did not have any experience in the submarine communication cable industry. The content and application providers have contracts with traditional telecom operators that operate their cables. Facebook does not want to obtain an 'international operator license' (Violari, 2017). It does not consider itself as telecom provider. And therefore the investments are made in collaboration with the telecom providers. In 4.4.4 the motives for investments in submarine communication cables for CAPs are discussed. The experience in the submarine industry of the CAPs is much lower than the service providers.

4.4.4 Organizational resources: Data services and consortia

On the next page organizational resources of the Facebook and Microsoft are listed. These are the data services that can be provided by the companies and the participation of the firms in consortia of submarine communication cables.

Data services that can be provided:

- **Facebook:** They only use the submarine cables capacity for their own application services. There are currently no plans to bring the remaining non-used capacity of the MAREA cable to the interconnection market (Violari, 2017). Therefore the data services of Facebook are not the sales of data transit. Instead they sell 'Facebook applications'. The submarine cable is part of the supply chain for these services.
- **Microsoft:** Microsoft sells their 'Azure cloud applications' (Microsoft, 2018). The submarine cables are part of the supply chain for these services. The rest capacity of the cables is not brought to the market. According to D. Crowley of Microsoft "we do not have the expertise of a telecom carrier" (Crowley, 2017) Instead Microsoft exchanges capacity for capacity on other routes.

Participation in consortia:

- **Facebook**: participates in a small number of small consortia for their cables. (Teleography, 2017). For example for the MAREA cable the consortium only consisted of three investors which are Microsoft, Facebook and Telxius. This means two CAPs and a telecom provider to operate the cable (Microsoft, 2017). However Facebook is also involved in slightly larger consortia such as the JUPITER cable which crosses the Pacific. This cable has six consortium members.
- **Microsoft**: invests mostly in small number of small consortia for their submarine cables. The consortia usually consist of less than ten investors (Teleography 2018). An example of such a project is the New Cross Pacific Cable System. This consortium has seven consortium members. They are also involved in the transatlantic MAREA cable which has only three investors (Microsoft, 2017).

Facebook and Microsoft do not bring the data capacity of their submarine communication cables to the interconnectivity market. The companies use the capacity of the cables for the interconnectivity between their data centers. The content and application providers do usually not participate in the large consortia of the telecom providers. Instead they create a smaller consortium with at least one telecom operator that can operate the cable for the content and application providers (Violari, 2017; Crowley, 2017). CAPs invest in submarine communication cables because they are part of the supply chain of their applications.

4.4.5 Investment strategy of content and application providers

The content and application providers started to invest in submarine communication cables to create long term connectivity, diversity for a reliable network and sufficient capacity for future applications (Crowley, 2017; Violari, 2017). The content and application providers therefore will invest in cables that connect easily to terrestrial backhaul connections to their datacenters and use different routes than the existing submarine cables. This creates a more reliable and high quality connections between their global datacenters. In this way they have more control over the infrastructure for the data transit which is required applications. Microsoft and Facebook have sufficient capital resources to invest in submarine cable systems in a small consortium. However they lack the technical experience to operate the cables by themselves. Therefore the content and application providers include a telecom operator in the consortium, which will operate the cable (Crowley, 2017; Violari, 2017). All consortia in which either Microsoft or Facebook is involved has at least one telecom provider (TeleGeography, 2017).

4.5 Resource based view applied to a public enterprise

The next step is to apply the resource based view to analyze Relined, a public enterprise of the government of the Netherlands. "Relined is the leading independent supplier of unused Dark Fibre capacity within existing public and private fibre optic networks in the Netherlands and Germany. Working in partnership with our preferred suppliers BT, ProRail and TenneT, Relined supplies Dark Fibre connections throughout the Netherlands and Frankfurt" (Relined, 2018). Relined is a state enterprise which is commercially branded. The shares of the organization are owned completely by Tennet the public enterprise which the electricity transmission system operator of the Netherlands (TenneT, 2018).

4.5.1 Physical resources: Backhaul infrastructure

Below a description of the backhaul networks is provided that are owned by the Relined.

- **Relined:** mostly manages the non-used capacity of fiber networks in the Netherlands. The organization manages the networks of TenneT (electricity transmission system operator), Prorail (government agency for the rail infrastructure) and British Telecom (R. Weijers, 2017). Relined is for fifty percent owner of the COBRA, a submarine fiber between Denmark and the Netherlands. The COBRA fiber is part of the cobra electricity cable. Relined will invest in a terrestrial backhaul connection to the COBRA cable.

Relined had the opportunity to add a submarine fiber to an electricity cable that was constructed by TenneT and Energinet. Since the public enterprise has a commercial character it decided to add a fiber cable to the electricity cable since this was very cost-effective. The optic cable consists of 48 fibres of which 6 fibres are reserved for the control system of the energy providers and 4 fibres as stand-by. The aim of this cable is to provide better backhaul services for their customers. (Weijers, 2017).

4.5.2 Capital resources: Revenue and CAPEX

The organization is a public enterprise and is completely owned by another public enterprise which is TenneT. TenneT is state owned and therefore the revenue and CAPEX of the organization are not considered relevant.

4.5.3 Human capital resources: Experience in the submarine industry

The level of human capital resources is described by discussing the experience of the public agency in the submarine industry.

- **Relined:** does not have experience in the submarine industry. The COBRA cable is the first submarine communication cable of this public organization. There is no experience in the organization to operate a submarine communication system (Weijers, 2017).

Relined has only one investment in a submarine communication cable, which is the COBRA cable. Relined invested in this cable because there was already an electricity cable placed on the route. Adding glasfiber to the cable could be done for a fraction of the usual costs. 2017. The organization only has experience in renting dark fiber and does not operate cables themselves (Weijers, 2017)

On the next page the organizational resources Relined are listed. These are the data services that can be provided by this organization and the participation of this organization in consortia for the investments in submarine communication cables.

Data services that can be provided:

- **Relined:** The organization only offers dark fiber. Relined does not provide 'lit networks' (Weijers, 2017) Companies that rent the dark fiber have to operate the networks themselves.

Participation is consortia:

- **Relined:** is in collaboration with the Danish Energinet for the construction and operation of the COBRA cable. The southern half of the cable is owned by Relined and the northern half by Energinet. The public enterprise also has other commercial relationships, but not for the investment in cables (Weijers, 2017).

Normally Relined only offers dark fibre. However for the COBRA cable Relined is considering four other options (Weijers, 2017). These options are:

- Rent a part of the cable to a tenant which invests in a private cable to the landing point of the Cobra cable or uses the backhaul network of Relined.
- Auction the data capacity on the cable to maximize value.
- Sell the dark fibre to a third party, which then can rent the cable to other companies. The third party can deliver higher quality of services such as coloured fibre, managed fibre. Relined does not have to knowledge to deliver these services by itself
- Offer fibre connections between Amsterdam and Denmark as a product.

4.5.4 Investment strategy of Relined

Relined is public enterprise which is commercially branded. The organization manages and rents rest capacity of the backhaul fiber connections in the Netherlands. The company has very little experience in developing products for backhaul fiber connections and only rents dark fiber (Relined, 2017). As part of a new electricity cable of TenneT, the electricity infrastructure incumbent of the Netherland, Relined can at a low cost place a submarine fiber between Netherlands and Denmark. The strategy of Relined is to bring the rest capacity to the market for market prices. (Weijers, 2017) Besides the construction of terrestrial backhauls to the COBRA landing, Relined will not invest in other submarine communication cables in the near future. Therefore there is no real investment strategy of Relined. The Cobra cable was a unique opportunity to invest and improve the backhaul connectivity of the Netherlands.

4.6 Conclusion

The goal of this chapter was to understand the investment strategies of the different types of investors based on an analysis of their resources. This chapter analysed with help of the resource-based view three types of investors in submarine communication cables. These are the telecom providers, the content and application providers and a public enterprise. As expected the three different types of investors have different motives to invest in submarine communication cables. The analysed telecom providers already have global networks which they use to sell a large variety of transit data services. The construction of submarine communication cable systems involve high costs and therefore most of the telecom providers co-invest in large consortia to share the risk. Since most of the telecom providers already have a network they regularly upgrade submarine cables instead of investing in new systems. The strategy of most of the telecom providers is to connect regions which have large demand for data transit. New connection will be linked to the larger network of the telecom provider. The telecom providers have a legacy network which also partly determines their investments. For example, Telxius has already an extensive network to South-America. The fact that they have this network influences their investments in submarine communication cables. Appendix R is an example of this focus on South-America.

Content and application providers have a different motive to invest in the submarine communication cables. Companies such as Microsoft and Facebook do no invest to sell the capacity of a submarine cable as a data transit service. Instead they use the capacity for the interconnection between their datacentres around the world. The capacity of these cables is used for current application and future products of these companies. Figure 20 shows the location of the datacentres of Microsoft, Facebook, Amazon and Google. The focus of content and application providers is not to make money of a cable. Their business strategy is to sell a service or an application. Microsoft for example sells their Azure cloud services. In order to be able to provide this service to the customer with a sufficient speed and reliability they invest in own infrastructure. (Crowley, 2017)

Relined is a public enterprise and usually does not invest in submarine communication cables. However the construction of a submarine electricity cable provided an opportunity to invest in a new submarine fibre between the Netherlands and Denmark. For the future there are no new plans for government cable investments (R. Weijers, 2017) Relined is only likely to invest in new submarine cable if another low cost opportunity will present itself.

4.7 Resource-based view factors for the comparative study

Based on the analysis of this chapter a number of factors can be identified which can be used in chapter 7 in the explanatory model. Chapter four concluded that telecom providers, content and application providers and public organizations have different investment strategies. Therefore the investors will be influenced by different factors for the decision in which countries a new cable will land. For this reason the identified factors are split up in three groups; telecom providers, content and application providers and the public enterprise.

The resource based view showed that the business strategy of telecom providers is mostly to sell transit over their extensive networks. Their current network assets are an important factor they consider. Usually telecom providers will only invest in a new cable when there is specific demand for data between regions. In places with low transit prices the investments in cables are less likely. Therefore the following factors have been identified that explain the investment behavior of telecom providers.

Telecom providers:

- Is there an important economic center in the region? (Large economic centers attract investments in submarine communication cables of telecom providers)
- Are there backhaul connections and landings station available close to the shore? (Existing backhaul connections make it much easier to land a new cable)
- Do current telecom operators have to amortize their cable in the short term? (It is likely that telecom providers want to invest in a new submarine fiber if this link is important in their network)
- Is the submarine fiber market liberalized? (Sometimes it is not possible to invest in connections with countries that did not liberalize the telecom market)
- What are the transit prices for a certain route and is there a lack of supply?
- What is the geographical location of a country?

Content and application providers have a different business case. Large CAPs own datacenters around the world which form the content delivery network of their services. Companies such as Microsoft invest in cables to secure the infrastructure between there datacenters. Therefor they buy existing cables or invest in new cables with an alternative route to diversify their network. (Violari, 2017; Crowley, 2017) The goal is to create reliable connections between the datacenters which are the infrastructure of the content and applications.

Content and application providers:

- What is the number of submarine communication cables that land already in the country? (CAPs want to diversify their data network. They are less likely to invest in submarine communication cable to an already well-connected part of a country)
- Are there backhaul connections and landing stations available close to the shore? (Existing backhaul connections make it much easier to land a new cable)
- Is the submarine fiber market liberalized? (Sometimes it is not possible to invest in connections with countries that did not liberalize the telecom market)
- Does a connection to a country add more diversity to the network?

Government enterprises such as Relined usually do not invest in submarine communication cables. However with the construction of an electricity cable a submarine cable can be added. Therefore the follow factor is added.

Public organization

- Will there be in the near future a construction of a new submarine electricity cable? (The construction of a new submarine electricity cables might provide a public organization the opportunity to add an optic cable to the sea cable)

4.8 Reflection on the application of the theory

The assumptions of the resource-based view are firm resource heterogeneity and immobility. In other words there are differences between the resources that firms in the same industry have and sometimes these resources cannot be duplicated by the other firms. Beneficial resources which cannot be duplicated can create a sustainable competitive advantage for this individual company (Barney, 1991). There are a number of benefits of the use of the resource based view. Resource-based view enables to understand the connection between the physical resources, the (human) capital and the organizational resources of the different companies and the effect on the investment strategy. The theory was a helpful tool to do this type of analysis in a very structured manner. The historical uniqueness of the submarine networks and the experience in the submarine industry can explain why there are differences in investments between telecom operators and content and application providers. Especially the business cases of telecom operators were explainable based on their firm attributes.

However a disadvantage of the theory is that it proved less useful to analyze the investments of platform companies. In this chapter the firm resources of the platform companies were analyzed. It is hard to explain the strategy of platform companies based on their resources. The problem is that their business case and added value is not directly related to their network. Companies such as Facebook and Microsoft sell a platform product. Developments in these platform products will influence their investment decisions in submarine communication cables. The resource-based view was not suitable to analyze these developments.

A second disadvantage of the resource-based view is that is was able to describe the differences in the use of consortia between ISPs and CDNs. However the theory was not able to explain the underlying reasons for this behavior. Also the investment behavior of Relined, the governmental organization, could not be only based on their assets. The reason is that they have other reasons for investments which can be politically driven.

Chapter 5: Analysis with transaction cost theory

In chapter four it was concluded that telecom and content providers, governmental bodies and content and application providers have different resources which explains the differences in investment strategies. In chapter five the transaction cost theory is used to analyze in detail why some content and application providers choose to invest in an own submarine optic fiber. This provides a part of the answer to the second sub-question: **'*Which factors influence investments in submarine communication cables?*'**

5.1 Structure of the chapter

In 5.2 the transaction costs theory is introduced. This paragraph also discusses the specific application of the transaction cost theory for the investments in submarine optic fibers. The properties of the transactions for contracts between telecom carriers and content providers are described in 5.3. With this information an overview is created in paragraph 5.4 which shows different governance structure options for content and application providers. This paragraph extensively discusses the differences between the different modes of governance. Than in paragraph 5.5 the advantages and disadvantages of the different modes of governance are analyzed. It also discusses the differences between the modes of governance and whether the theory is helpful to explain the current investments of content and application providers in submarine optic fibers. Then in paragraph 5.6 based on the theory and the analysis the factors for the explanatory model for submarine investments are identified. Lastly, paragraph 5.7 reflects on the application of the transaction cost theory for the analysis of the vertical integration of content and application providers.

5.2 How to apply the theory?

First the transaction cost theory is introduced in 5.2.1. Then, 5.2.2 explains in detail how the transaction cost theory is applied to analyze contracts between telecom providers and content and application providers to understand the vertical integration behavior of content and application providers. In this way insight is created of the incentives of content and application providers to invest in submarine communication cables.

5.2.1 Repetition of the literature

Niesten (2009) provides a compact overview of the literature of transaction cost theory. Niesten summarizes: "Transaction cost economics concurs with John R. Commons, who stated that 'the ultimate unit of activity must contain in itself the three principles of conflict, mutuality and order. This unit is a transaction." (Commons, 1932, p. 4). The transaction is the basic unit of analysis in transaction cost economics. A transaction occurs "when a good or service is transferred across a technologically separable interface. One stage of activity terminates and another one begins" (Williamson, 1985, p. 1). Transaction costs are often described as 'the costs of running the economic system' (Arrow, 1969, p. 48). "They include the costs of bargaining, drafting, negotiating and safeguarding an agreement. These are referred to as ex ante transaction costs; they are incurred before the intended transaction takes place. In addition, transaction costs include costs of planning and monitoring task completion. And finally, there are ex post transaction costs, such as costs for enforcing and policing an agreement, and misalignment costs. Transactions can become maladapted to the structures that govern them, because of the unanticipated disturbances to which transactions are subject. This misalignment creates various ex post transaction costs, including (1) the maladaptation costs; (2) the haggling costs incurred if bilateral efforts are made to correct ex post misalignments; (3) the setup and running costs associated with the governance structures to which disputes are referred; and (4) the bonding costs of effecting secure commitments" (Williamson, 1985, p. 21).

The transaction cost theory can be applied to manage the transaction costs involved with the creation and operating of a submarine connectivity cable. This can be either through contracting with telecom operators or with a greater or lesser degree of vertical integration. Transaction cost theory is a powerful tool to understand and explain the development of vertical integration. This is when firms take control of more processes in the supply chain. Analyzing the characteristics of the transaction is useful to explain to which extend vertical integration is expected. According to Williamson (1991): "The empirical literature reveals a consistent preference for integration over contracting as the specificity of investments increases. Thus, whereas asset specificity favors contracting when the alternative is simple exchange, contracting becomes less attractive as a way of protecting reliance or relationship-specific investments where the alternative to contracting is integrated ownership and production. Contracting thus appears to be only an imperfect response to the hazards posed by relationship-specific investments. Second, the evidence indicates that uncertainty and complexity also diminish the attractiveness of contracting relative to integration (e.g., Masten [1984]; Anderson and Schmittlein [1984], p288). Together with the evidence that uncertainty and complexity discourage contracting relative to simple exchange, these findings reinforce the conclusion that contracts are a costly and inflexible way to provide for future adaptations".

5.2.2 The application of the theory

The literature from 5.2.1 suggests that the interactions between telecom carriers and content and application and the degree of vertical integration can be explained by the characteristics of the transactions. The characteristics of the transaction have to be aligned with the suitable mode of governance to minimize the transaction costs. Content and application providers will try to minimize the transaction costs and therefore this will help to understand their choice for the mode of governance. Therefore the analysis focusses on understanding under which content and application providers will use contracting and when they use a form of vertical integration. This information is useful since it helps to understand the investment strategy of the content and application providers.

The first step of the analysis is to describe the properties of transaction for contracts of submarine transit data. According to Williamson (1991) and Klein (2014) the properties of the transaction costs can be analysed by describing the asset specificity, the uncertainty and the frequency of the contracts. Table 9 shows the different types of asset specificity, uncertainty and frequencies that will be analysed. The asset specificity can be split up in site specificity, human asset specificity, brand-name capital specificity, physical asset specificity, dedicated assets and temporal specificity (Williamson 1991a). These different types of asset specificity are discussed separately which lead to a conclusion about the asset specificity and thus the complexity of the transaction.

Table 9 - Application of the theory: Properties of the transaction

Properties of the transaction	
Asset specificity	Site specificity Human asset specificity Brand-name capital specificity Physical asset specificity
Uncertainty	Environmental uncertainty Behavioural uncertainty
Frequency	Frequency of the contract

The uncertainty is split up in environmental uncertainty and behavioural uncertainty. "Environmental uncertainty does not refer to judging human behaviour on whether actions are sustainable in an environmental/ecological sense, but refers to uncertainty as to the way the human environment is developing. Environmental uncertainty stems mainly from unanticipated changes in factors or conditions that affect transactions" (Haase, N. 2009, p88). The environmental uncertainties are divided in the categories, technical, economic and regulatory uncertainty. 'The behavioural uncertainty: is deduced from the bounded rationality assumption that New Institutional Economics is based upon. Humans are limited in their capacities to process information and may further behave in an opportunistic way. Behavioural uncertainty refers to ex post opportunistic behaviour by one contracting partner. (Haase, N. 2009, p87) Since the behavioural uncertainty is dependent on the specific governance structure, this uncertainty is dealt with in the next step of the analysis. The last assets specificity that is discussed is the frequency of the exchanges. In this part the frequency and type of the contracts between content and application providers and telecom carriers for submarine transit data are evaluated.

After the analysis of the properties of the transaction cost it is time to take the next step. The different types of modes of governance for submarine data transit for content and application providers are analysed. There are different forms of contracting which are various types of long term contracts, joint ventures, dual sourcing (partial vertical integration), holding companies, and public enterprises. (Joskow, 2003) According to David Crowley of Microsoft these different types of governance structures can indeed be used for the data transit between the data centres. In this analysis we will compare; small short term scale data contracts, long term transit contracts, co-buying submarine communication cables with telecom carriers and co-construction of submarine cables, since these types of contracting were all used by Microsoft (Crowley, 2017) The governance structure 'full ownership' is added to the diagram to provide a full overview of the advantages and disadvantages of different governance structures. For every mode of governance the ex-ante and ex-post transaction costs are discussed. Also the economic, technologic and regulatory uncertainties involved with a certain type of governance structure are discussed. These uncertainties involve also the behavioural uncertainties which are related to the mode of governance.

Table 10 - Evaluation of governance structures based on (Williamson, 1991a)

Evaluation of the modes of governance	
Transaction costs (Ex ante)	Costs of bargaining Costs of drafting Negotiation costs Safeguarding and monitoring
Transaction costs (Ex post)	Maladaption costs Haggling costs Setup and running costs Bonding costs
Asset specificity	Level of complexity
Uncertainty	Technological Regulatory Economic
Frequency	Frequency of the contracts

The last step of the analysis in this chapter is to compare the different types of governance structures. What are the differences in ex-ante and ex-post transaction costs? Furthermore which different types of uncertainties are involved with the different modes of governance? The comparison of the different modes of governance is used to understand which type of contracting/vertical integration is used by which type of content and application provider. The outcome of the analysis provides insight in the investment strategy in submarine communication cables and the interaction with the telecom providers. According to the theory when asset specificity and uncertainty are both high, contracts may be insufficiently flexible, leading to vertical integration instead. (Williamson, 1991a)

In the last analysis step the theoretical insights and outcome of the analysis with inputs of the interviews and industry documents is the bases for the factors of the explanatory model for submarine communication investments in chapter 7. Moreover it reflects on the explaining power of the transaction cost theory for vertical integration.

5.3 Properties of the transaction

The asset specificity, environmental uncertainty and frequency are discussed in respectively sub paragraph 5.3.1, 5.3.2 and 5.3.3. Subparagraph 5.3.4 summarizes the properties of the transaction and discusses the 'level' for data transit contracts.

5.3.1 Asset specificity

Site specificity

There is high site specificity involved in the contracts between content providers and the telecom carriers. Content and application providers have specific site-related demands for submarine data transit. For example the strategy of Microsoft is to interconnect the datacentres (Crowley, 2017). These data centres have locations all around the world and therefore site specific connections are required to create connectivity between these data centres. In this way a 'Point of Presence' for their heavy traffic can created to a certain location (Fisk, 2017) For certain route only a few transit data suppliers might have the right infrastructure to provide the needs of the content and application provider.

Figure 19 provides an overview of the Trans-Atlantic regional market of submarine optic fibres. Most cables connect the north-east coast of the United States with the north Europe. Until the MAREA cable there were no direct cables between the United States and the South of Europe. For example direct demand for data transit between the United States and the South of Europe could not be fulfilled; hence there is very high site specificity.

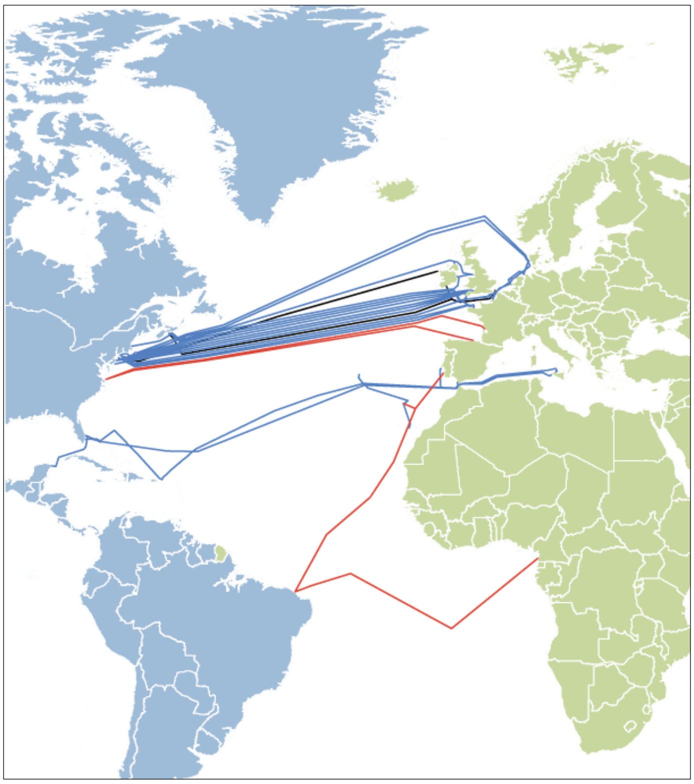


Figure 19 - Overview of the Transatlantic Regional Market (SubOptic; Submarine Telecoms Forum, 2016)

The demand for transit data is changing. Submarine Telecoms Industry Report argues that: 'Data centre and content provider companies are becoming increasingly responsible for new system demand; especially for the Americas, Transatlantic, Transpacific and Austral-Asia regions. These companies, such as Facebook, Google, Amazon and Microsoft, are consuming bandwidth at an increasingly rapid pace.' The content and application providers want to have multiple connections between there data centres around the world (Violari, 2017; Crowley, 2017)

Figure 20 shows the global data centres of the four large content and application providers. The datacentres of Amazon, Google, Microsoft and Facebook are located close the coasts. Datacentres of the CAPs in Europe are located in the north. The transit demand data of the companies is very site specific. Content and application providers want to have 'diversification of cables for resilience and security.

Physically diverse routes are a requirement for most users and are especially important for content delivery networks' (Analysys Mason, 2018).

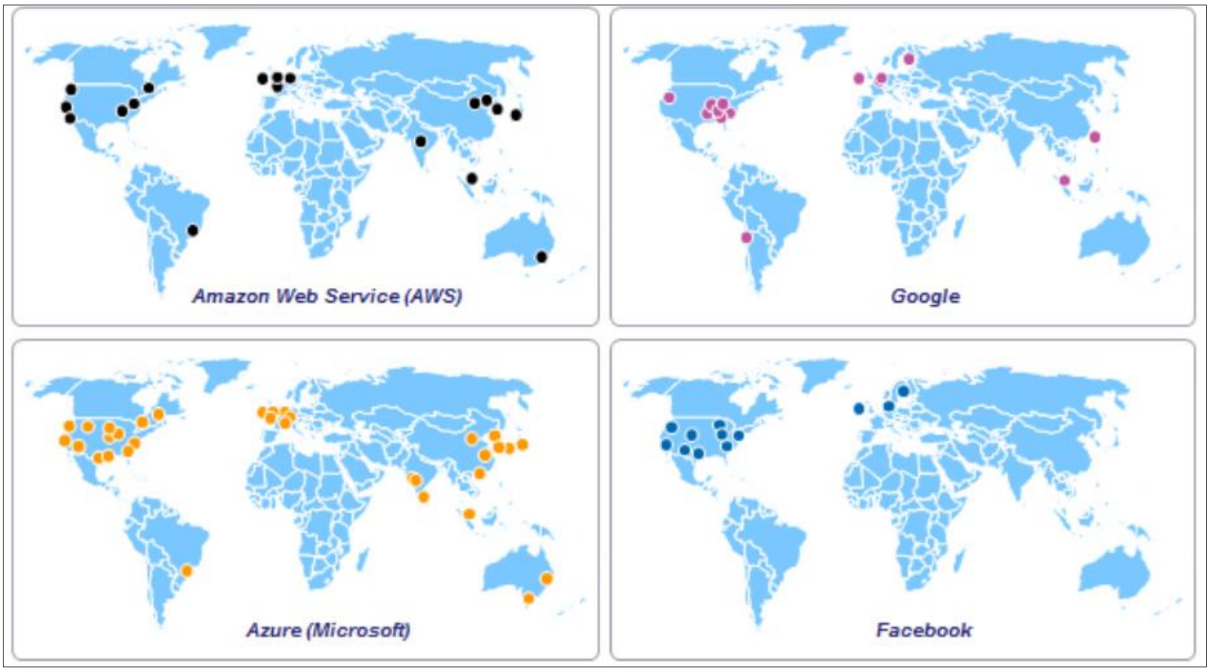


Figure 20 - Sample of content providers' global data centres (Analysys Mason, 2018)

<u>Human asset specificity</u>

Human asset specificity 'describes the transaction-specific knowledge or human capital, achieved through specialized training or learning-by-doing' (Williamson 1991a).According to Melina Violari of Facebook Telefónica has experience in the submarine communication cable industry. (Violari, 2017) Transaction-specific knowledge is likely to arise when content and application providers and telecom carriers have a long term contract for data transit. The telecom carrier can get deep insight in the specific demands in the demand of the CAP. Through 'learning-by-doing' the human assets can optimize the transit of data.

<u>Physical asset specificity</u>

According to Wiliamson (1991a) the physical asset refers to relationship-specific equipment and machinery. There is physical asset specificity involved. Specific equipment is required that 'beams' the dark fibre connection. Specific physical assets are required to send signals over the fibre, to switch and to receive signals. The type of equipment that is used will influence the latency, the capacity and flexibility of the system. Content and application providers increasingly require more and more data transit capacity (Violari, 2017) Specific physical assets are required to meet this high capacity demand of content and application providers or routs with low latency. (SubOptic; Submarine Telecoms Forum, 2016) In paragraph 2.2.2 the different types of cable technology that are available are discussed. Content and application providers can have specific physical asset demands. Additional physical asset specificity exists in the interface between the data centres and networks of the telecom carriers and the networks and datacentres of the content and application providers.

Dedicated assets

Dedicated assets are 'substantial, general-purpose investments that would not have made outside a particular transaction, the commitment of which is necessary to serve a large customer' (Williamson 1991a, p. 281). Some specific data transit demand requires investments in new specific submarine communication cables by telecom carriers. An example of such a dedicated asset is the construction of a very low latency cable for financial institutions, such as banks and financial traders. These institutions can compete sometimes in 'winner-takes-it-all market' (T. Fisk, 2017) In order to be profitable the traders need to have the lowest latency connection to be profitable. This type of clients demand very dedicated assets. In the future content and application providers such as Facebook might also require very low latency cables (M. Violari), which require dedicated assets of a telecom carrier.

5.3.2 Environmental uncertainty

Technological uncertainty

The largest technological risk is the risk of a cable cut of the submarine communication cable. Cable owners such as British Telecom, KPN and Telfónica/Telxius indicate in that cable cuts involve high costs. Besides the costs of the repair of the cable it is possible that cable cuts create extra costs for the owners because of the lower price due to the lower reliability (Relined, 2017) The cable cuts are also a risk for the content and application provider because they have a decreased reliability and might experience loss in performance, which cable cuts can be caused by different factors. Examples are geological events, such as landslides, earthquakes, tsunami and shipping activities such as fishing nets and anchors (Telefónica, 2017) (KPN, 20170) The risks and the costs of a cable cut depends on the length of the system, the design and the earlier mentioned external factors. Shallow waters increase the chances of a cable cut. (Palmer-Felgate & Booi, 2016). Uncertainty about the possibility of the feasibility of the cable repair itself. Sometimes the cables break in a certain area where it is hard to repair, which can create large additional costs (Palmer-Felgate & Booi, 2016). Sometimes it is even unsure whether the cable will be repaired at all. For instance, the Cobra cable of Relined which connects Denmark and the Netherlands is attached to an electricity cable. The electricity cable has priority over the data cable. Therefore the communication cable will not be repaired if the cable is broken, while the electricity cable is still in function. (Relined, 2017)

The development of technology creates uncertainty for the suppliers of transit data. New technological developments create higher quality demand for the infrastructure by the data users. Changes in latency requirements can be a large risk for cable owners (KPN, 2017). Lastly, there is uncertainty about what kind of products will be developed in the future by the content and application providers. This uncertainty about the products also creates uncertainty in what technical requirements are required for the data transit connections. (Facebook, 2017) (Microsoft, 2017)

Economic uncertainty

There is uncertainty about the supply of the right data transit service in the future. Facebook and Microsoft are uncertain if there will be enough transit data capacity available in the future (Violari, 2017; Crowley, 2017). New products might use large quantities of data which require the high capacity connections. Current telecom carriers might not have enough capacity on certain routes to meet this demand. However Mr. de Booi, from Verizon says that the contrary is true. According to him there is a risk that bubbles are created. Especially in the Pacific and in Asia there are a lot of submarine communication cables constructed. This rapid increase in transit connections due to the construction of new cables could decrease the price of transit traffic which creates uncertainty for the business operations of the telecom operators. However underinvestment could create scarcity.

The rate in which the transit data demand will rise is unsure. Regionalisation of data due to the use of content delivery networks might decrease the expected growth in transit data demand (Verizon, 2017) Therefore there is price uncertainty. Large investments have to be made by companies for the construction of submarine communication cables. Due to demand uncertainty there is a risk that the construction costs cannot be earned back in the short notice (Telefónica, 2017).

Regulatory uncertainty

There is uncertainty for telecom carriers and content and application providers whether the international standards of the ESCA/ ICPC regarding submarine communication cables will be complied by countries in their territorial waters. According to British Telecom the maintenance zones as defined in the international standards are important for safe repair activities. Policies such as reducing the guaranteed maintenance zones around existing cable might introduce problems for telecom carriers because of the lack of space. This is discussed in more detail in chapter 6. There is also regulatory uncertainty regarding the connections between countries that have conflicts. For example in the case of a cable between Taiwan and Japan no direct cables are possible due to political tension. The governments will not allow a direct cable to the other country. However in these cases branching units could be a solution. An indirect cable could nonetheless connect the countries (Verizon, 2017).

Regulatory uncertainty can also arise because of internet traffic interception by nation states. It is possible that the costumer of the transit data does not want that the information is shared with certain nations. This can put pressure on the telecom carrier and can create problems (Facebook, 2017) Obtaining landing permits for a new cable landing and obtaining working licenses can also be a source of regulatory uncertainty (Facebook, 2017) Content and Application providers might also experience regulatory uncertainty if they want to invest in submarine communication cables. These parties do not want to be defined as telecom operators, because of the more strict regulations for these types of companies. Therefore companies like Facebook prefer not obtaining an international operational license (T. Fisk, 2017)

5.3.3 Frequency

The contracts between telecom operators and content and application providers depend on the type of data service. For example basic services such as dark fibre will have a longer contract length. The minimum contract length for dark fibre from Relined is five years. (Relined, 2017) This is logical from a cost perspective, because the data using party has to invest in own infrastructure to be able to use the cable (Relined, 2017) Higher level data services such as IP transit have shorter contract lengths. For instance KPN IP-transit contracts have a minimum contract length of 1 year (KPN, 2018).

5.3.4 Summary of the transaction properties

Paragraph 5.3 showed that contracts between content and application providers have high site specificity, physical and human asset specificity. There are a lot of environmental uncertainties involved with the contract including technical uncertainties. The most important technical uncertainty is due to cable cuts. Besides the technical uncertainties there are also regulatory and economic uncertainties. Content and application providers should use the right mode of governance to face this complexity. In the next paragraph the different modes of governance are discussed.

5.4 Comparison of the different governance structures

In paragraph 5.4 discusses five modes of governance which large content and application providers can choose to obtain transit data. These modes of governance are; in 5.4.1 short term contracts, 5.4.2 long-term wholesale contracts, 5.4.3 co-buying, 5.4.4 co-construction and 5.4.5 full ownership. For every type of governance structure the ex-ante and ex-post transaction costs and the specific asset specificity, (behavioral) uncertainty and frequency is discussed.

5.4.1 Short-term transit contracts

Table 11 shows the transaction costs and other effects of short-term contracts with telecom operators. The ex-ante transaction costs of bargaining are high since contracts have to be renewed often. However since the length of the contract is relatively low the contract drafting costs are low. The ex-post maladaptation costs are high since one content and application provider can have a large number of contracts with different companies. These companies will not be adapted to the business operations of the content and application provider.

Table 11 - Effects of short term contracts between content and application providers and Telecom Operators

Mode of governance:	**Small short-term contract with a Telecom Operator**
Transaction costs (Ex ante)	
Costs of bargaining	High: small scale contracts are usually for a short period of time, therefore there is a lot of bargaining required
Costs of drafting	Moderate
Negotiation costs	Low: due to the short length of the contract the risks are relatively low

Safeguarding and monitoring	Moderate
Transaction costs (Ex post)	
Maladaption costs	High: large number of different contracts which increase the maladaption cost
Haggling costs	Low
Setup and running costs	High
Bonding costs	Low
Asset Specificity	High for both CAP and Telecom Operator
Uncertainty	
Technological	High: Due to complete dependence on the technology of telecom carriers there is high risk for their future products. There is information CAPs are completely dependent on the Technology of telecom operators. This information asymmetry between the CAP and the telecom operator, which might lead to optimistic behavior of the telecom Carrier.
Regulatory	Low
Economic	High: Due to the short contract length there are high data transit costs (Microsoft, 2017) Furthermore there is a lot of uncertainty regarding the future price of data transit for a certain route
Frequency	High

Short-term data transit contracts involve high technological and economic uncertainty for large content and application providers. Since there is no bonding with the telecom operator the content and application provider is dependent on the technology of the telecom operator. It is not possible to steer the technological developments. From an economic perspective there is also a lot of uncertainty. Since the contract length is short depending on the business cycle there is uncertainty about the price and availability of transit data in the future for certain routes.

5.4.2 Long-term wholesale data contracts

Long-term wholesale data contracts are much cheaper in comparison with short term contracts according to Mr. Crowley from Microsoft. According to him: "Microsoft started to buy services from telecom carriers, which cut costs by 63% in comparison with short-term contracts" (Crowley, 2017) The ex-ante transaction costs for long-term wholesale contracts have high costs of drafting, safeguarding and monitoring, as showed in table 12. Due to the longer contract length the contracts are more complex and safeguard and monitoring mechanisms are required. Ex-post maladaptation costs are likely to be lower since the telecom operator and the content and application provider have only to adapt one time. However the haggling costs of long term contracts are high. The requirements for transit data of the content and application provider may change over the years. The contracted telecom provider might behave opportunistic by underinvesting in the transit infrastructure due to the 'lock-in' of the content and application provider. This underinvestment can have a negative effect on the capacity, reliability and technical capabilities of the network. There also might be expropriation of quasi-rents when new types of data transit services are required due to the lock-in of the content and application provider.

Table 12 - Effects of long-term wholesale data contracts between content and application providers and transit providers

Mode of governance: **Long-term wholesale data contracts with telecom operators**	
Transaction costs (Ex ante)	
Costs of bargaining	Moderate: The whole sale contracts require lower costs of bargaining because there is less often bargaining required
Costs of drafting	High: Long term contracts are complex
Negotiation costs	Moderate
Safeguarding and monitoring	High
Transaction costs (Ex post)	
Maladaption costs	Moderate: Due to the long term relationship the maladaption costs are be reduced in comparison with the small scale contracts
Haggling costs	High: During the contract the CAP might develop new products. Different types of interconnection might be required for these products. However the telecom carrier might behave opportunistic ex post by under investing, which creates haggling costs. Expropriate the quasi-rents for new types of services.
Setup and running costs	Moderate
Bonding costs	Moderate: Both the CAP and the Telecom Carriers will have to make some investments in infrastructures and IT systems which creates bonding costs
Asset Specificity	High for both CAP and Telecom Operator
Uncertainty	
Technological	High: There is information asymmetry between the CAP and the Telecom Carrier. The Telecom carrier might underinvest in the infrastructure which might limit the reliability, capacity and technical specs of the transit connection (Facebook, 2017)
Regulatory	Low
Economic	Moderate: The long term wholesale data traffic contract reduces the price for data transit. Also it safeguards the risks for changing prices
Frequency	Moderate

5.4.3 Co-buying of a cable

Co-buying of a cable in a joint-venture with a Telecom Operator is a hybrid-form of vertical integration. The transaction costs ex-ante for the drafting of the contract is high. The contracts and organization of a consortium is complex (Simmons, 2014). The ex-post transaction costs for haggling are relatively low in comparison with long-term wholesale contracting.

Table 13 - Effects of co-buying with a transit provider

Mode of governance: **Co-buying with at least one Telecom Operator**	
Transaction costs (Ex ante)	
Costs of bargaining	Low: Only one time a contract is made, which means relative low initial bargaining costs
Costs of drafting	High: Partial ownership requires complex contracts in a consortium.

Negotiation costs	High: A large number of aspects have to be negotiated. Examples are: upgrade procedures, ownership and maintenance.
Safeguarding and monitoring	Low
Transaction costs (Ex post)	
Maladaption costs	Low: Only once the cable has to be adapted for the services. Furthermore it is assumed that the CAP investments in a cable which involves low adaption costs
Haggling costs	Moderate: Haggling costs between the owners of the cable might occur when upgrading the submarine cable system.
Setup and running costs	Moderate: The submarine communication cable is ran by the Telecom Carrier
Bonding costs	Medium
Asset Specificity	High for both CAP and Telecom Operator
Uncertainty	
Technological	Low: the CAP has the specific technical information about the submarine system. It also has the possibility to upgrade the system if necessary. Furthermore the Telecom Carrier in the consortium can operate the cable, since they have the right experience with these systems (Facebook, 2017)
Regulatory	Moderate: Governments might define CAPs as Telecom Operators which increases the risk on stricter regulation. The Telecom Carrier in the consortium can take care of the required permits.
Economic	Low: The price of the submarine cable is known. However there can be extra costs can due to cable cuts or other external factors.
Frequency	Low

The ex-post setup and running costs are high since large investments have to be made in the new cable. However this investment pays out. Both the technological and economic uncertainties are low and the CAP has much more control over connections between the datacentres. The content and application provider can insist on upgrading the infrastructure if this is required for new products. The regulatory uncertainty is higher than the previous two types of contracting. Owning a submarine optic fibre pairs might provoke stricter regulation. However usually the telecom operator will run and operate the cable itself.

5.4.4 Co-built of a cable

Table 14 - Effects of co-buying with a transit provider

Mode of governance:	**Co-built with at least one Telecom Operator**
Transaction costs (Ex ante)	
Costs of bargaining	Low: Only one time a contract is made, which means relative low initial bargaining costs
Costs of drafting	High: Partial ownership requires complex contracts
Negotiation costs	High: A large number of aspects have to be negotiated. Examples are: upgrade procedures, ownership, and maintenance and construction specifications.

Safeguarding and monitoring	Low
Transaction costs (Ex post)	
Maladaption costs	Low: The specifications of a new cable can be partly decided by the CAP, because they co-invest
Haggling costs	Moderate: Haggling costs between the owners of the cable might occur when upgrading the submarine cable system.
Setup and running costs	Moderate: The submarine communication cable is ran by the Telecom Carrier
Bonding costs	Medium
Asset Specificity	High for both CAP and Telecom Operator
Uncertainty	
Technological	Low: the CAP has the specific technical information about the submarine system. It also has the possibility to upgrade the system if necessary. Reliability can also be controlled by the route selection of the cable. Furthermore the Telecom Carrier in the consortium can operate the cable, since they have the right experience with these systems (Facebook, 2017)
Regulatory	Moderate: Governments might define CAPs as Telecom Operators which increases the risk on stricter regulation. The Telecom Carrier in the consortium can take care of the required permits.
Economic	Moderate: Although the price of the submarine cable is known extra costs can be created because of cable cuts or other external factors.
Frequency	Low

As seen in table 14 co-building of a new submarine optic fiber has the similar transaction costs and effects to co-investment of an existing cable. However with co-construction the content and application provider has more control over the route of the cable. This is beneficial. In this way, CAPs can "expand requirements for diversity and redundancy" (Analysys Mason, 2018). This can lower the total technical risk for the CAP even more. The construction of a new cable however might be more expensive than buying fiber pairs on an existing cable.

5.4.5 Full cable ownership

Table 15 - Effects of co-buying with a transit provider

Mode of governance:	**Full ownership (Full vertical integration)**
Transaction costs (Ex ante)	
Costs of bargaining	High (Bureaucracy)
Costs of drafting	High (Bureaucracy)
Negotiation costs	High (Bureaucracy)
Safeguarding and monitoring	High (Bureaucracy)
Transaction costs (Ex post)	
Maladaption costs	Zero
Haggling costs	Zero
Setup and running costs	Zero
Bonding costs	Zero

Asset Specificity	High for the CAP
Uncertainty	
Technological	High: At first there will be high technological uncertainty due to the absence experience of how to run a submarine communication cable. The company however can hire specialists in this area. Furthermore there will be almost certainly too much data capacity available for the CAP.
Regulatory	High: Governments might define CAPs as Telecom Operators which increases the risk on stricter regulation. Furthermore the CAP might not easily obtain the right permits for a submarine cable landing
Economic	High: By solely investing in a submarine cable the CAP will have to make high investments. This will stable and predictable prices data transit instead of depending on the market.
Frequency	Low

Full cable ownership of a content and application provider involves high costs. Due to the lack of experience the technical uncertainty will be high. The economic costs are also being likely to be very high. Since the costs for the cable are not shared the investment and running costs will be high. On top of that it is likely that most of the data capacity will not be used. Another disadvantage for CAPs is the high risk for regulation that is involved with full ownership. Stricter regulations could harm the business model.

5.5 Evaluation of the different modes of governance

Table 16 provides a simplified overview of paragraph 5.4. The transaction costs and effects on uncertainty are coloured red, grey or green for respectively a negative, neutral or positive effect of a mode of governance. In the latest years content and application providers started to invest in own submarine optic fibres as discussed earlier. The Submarine Telecoms Industry Report 2015 notes: "A rather striking new development has emerged in 2016. Content providers — especially cloud services and data centre providers — are beginning to step into the world of submarine cable ownership. Many of these companies have such large and complex infrastructure requirements that it is becoming more efficient for them to simply own their own international links rather than buy capacity from an infrastructure provider. As a result, a significant portion of systems for 2016 to 2018 are largely driven by these companies" (SubOptic; Submarine Telecoms Forum, 2016, p. 27) Table 17 shows why it is indeed sometimes more efficient to invest in own infrastructure. As discussed in paragraph 5.4.3 long-term contracts can lead to opportunistic behaviour from the telecom operator. Underinvestment in infrastructure creates uncertainty regarding the security of supply of the services of content and application providers. Furthermore quasi-rents can be extracted by the telecom provider if content and application providers are 'locked-in' Co-buying and building reduces the technological and economic risks.

With co-buying or building the content and application provider can have more control over the technology. In this way companies as Facebook and Microsoft can increase the "development of shorter routes and more regional systems where markets are under-served (thin routes). These will help to increase the availability of inter-data center connectivity when combined with terrestrial networks … generation of new trans-ocean routes, which will largely be driven by the CDNs of the internet giants and their strategies for those parts of the globe that they are not currently addressing" (Analysys Mason, 2018). In other words the content and application providers are likely to invest in new cables which are land in areas which are not yet interconnected well. For interconnection between the United States and the North Europe it is less likely that these new companies will construct a new cable. For this route co-buying is a more logical option. This is exactly what Microsoft did. The company co-invested in the "Hybernia Express' of Aquacom to the United Kingdom, which today is called the 'GTT Express" (Crowley, 2017).

Table 16 - Overview of the effects of the different modes of governance

Mode of governance:	Small short term contract	Long-term wholesale contract	Co-buying	Co-built	Full ownership
Transaction costs (Ex ante)					
Costs of bargaining	High	Moderate	Low	Low	High
Costs of drafting	Moderate	High	High	High	High
Negotiation costs	Low	Moderate	High	High	High
Safeguarding and monitoring	Moderate	High	Moderate	Low	High
Transaction costs (Ex post)					
Maladaption costs	High	Moderate	Low	Low	Absent
Haggling costs	Low	High	Moderate	Moderate	Absent
Setup and running costs	Moderate	Moderate	Moderate	Moderate	Absent
Bonding costs	Low	Moderate	High	High	Absent
Asset Specifity	High	High	High	High	Absent
Uncertainty					
Technological	High	High	Low	Low	High
Regulatory	Low	Low	Moderate	Moderate	High
Economic	High	Moderate	Low	Low	High
Frequency	High	Moderate	Low	Low	Low

To sum up, large content and application providers increasingly co-buy and co-build submarine optic fibre to create high capacity infrastructure between their data centres. Most of the construction of these cables is done through the use of joint-ventures with other content and application providers and other telecom operators. In this way the CDNs can reduce technological and economic uncertainty to assure bandwidth for their future products.

5.6 Transaction cost economic factors for the comparative study

How can the outcome of the analysis be translated into factors for the exploratory model in chapter 7? This chapter showed that content and application providers are increasingly co-investing in submarine optic fibers. Co-investment mitigates most of the ex-post transaction costs such as underinvestment in infrastructure. The investments of new cables aim to directly connect datacenters, reduce the risk of data transit failure and create diversity in the supply chain (Violari, 2017; Crowley, 2017). Summarized the following factors were identified based on the TCE.

- Are there datacenters (CDNs) of one of the large content and application providers located in the country?
- Are there terrestrial backhaul connections which connect to the datacenters?
- What is the number of existing cables that lands in the country/region?
- Do the content and application provider already have an own cable to the country/region?
- What are the prices of existing submarine optic fibers that connect to the country?
- Is there sufficient room left on the current cables to rapidly increase capacity in the future?
- Does a cable to the country create more diversity in the network of the content and application provider?

5.7 Reflection on the use of the transaction cost theory

In this chapter the transaction cost theory was applied to understand the investment behaviour of content and application providers in submarine optic fibres. According to Williamson (1991a) when there is: "high asset specificity and uncertainty, contracts may be insufficiently flexible, leading to vertical integration instead. Also empirical studies in other industries confirm this theory, uncertainty and complexity diminish the attractiveness of contracting relative to integration (e.g., Masten [1984]; Anderson and Schmittlein [1984])". First it was showed that contracts for data transit between content and application providers and telecom operators involve high uncertainty and asset specificity. Therefore the theory predicts that some level of vertical integration is likely in the case of contracts between CAPs and telecom carriers. In this chapter we can conclude that this is the case. However vertical integration of submarine communication cables is only possible for large content and application providers since they require high investments. For this reason they will be more attractive for very large data transit users.

The transaction cost theory was helpful to analyse the relationships and relationships between the content and application providers and the telecom operators. By analysing transaction itself the new trend in vertical integration can be explained. Although in times of outsourcing the vertical integration of companies may seem a bit counter intuitive however the theory showed that due to the high technical and economic uncertainties and the transaction cost for contracting, vertical integration can be more beneficial.

The transaction cost economic theory has also a number of disadvantages. First of all the theory is flexible, which can be a negative and a positive property. The theory can be applied to a large variety of contracts in different ways. In other words the application of the TCE leaves a fair amount of decision-freedom for the analysts, which may influence the objectivity of the study. This can also be seen as a strong point of the theory, because it is flexible to analyse different types of transaction costs. Secondly the theory can only describe which governance structure minimizes the transaction costs. It also shows when transactions do not occur, when the right coordination mechanism is not possible or allowed. The theory is not suitable to explain the business cases of the companies itself. The theory is not useful to understand why companies and organization start to invest in submarine infrastructure in the first place at all. It simply assumes 'self-interestedness' of the actors.

Chapter 6: Analysis with transaction cost regulation

In chapter 6 the transaction cost regulation theory is used to analyze the effect of regulations on the investments in submarine communication cables. This chapter uses a case study of the Netherlands to describe the effect of government regulations on investments in submarine optic fibers to a country.

6.1 Structure of the chapter

First in 6.2 the theory of the transaction cost regulation is introduced. Can the framework be used in a non-utility environment? Furthermore it explains how the transaction cost regulation framework is applied to influence of governments on the firm investment behavior in submarine cables. Then in 6.3.1 the legal framework is discussed. In paragraph 6.3.2 the possible governmental opportunism is described. In 6.3.3 third party opportunism and its effects is discussed. Subsequently in paragraph 6.3.4 different ways of opportunisms are summed up and discussed. This discussion provides the input for the explanatory model in chapter 7. Lastly in paragraph 6.4 the use of the transaction cost regulation theory is discussed.

6.2 How to apply the transaction cost regulation framework?

First In paragraph 6.2.1 whether the transaction cost regulation framework can be applied to understand the submarine communication industry, because the framework was mainly developed for utility markets. Than in subparagraph 6.2.1 the literature of transaction cost regulation is introduced. Subparagraph 6.2.3 discusses the application of the theory.

6.2.1 Submarine optic fibers industry, a utility market?

The transaction cost regulation was developed to analyse utilities (Spiller, 2013). Therefore it is first discussed whether the framework can also be applied to analyse effect of government legislation on submarine communication cable investments. First the features of a utility have to be known. According to Spiller utilities have three fundamental features. "These features are; the products are consumed widely, they exhibit important economies of scale and scope at the relevant levels of demand and their investments are characterized by a high level of physical specificity (i.e., have a high component of sunk investments)" (Spiller, 2013, p. 234). The question is whether the submarine communication industry can be defined a utility. Transaction cost regulation framework is only applicable if the industry has the same characteristics as a utility industry.

The submarine communication cable industry meets the first requirement partly. The products are consumed widely, however indirectly. Due to the fact that submarine optic fibres are a vital part of the internet, by itself it is consumed widely. The second feature: "they exhibit important economies of scale and scope at the relevant levels of demand"(Spiller, 2013, p. 234) is partially met. Most telecommunication carriers have large international networks which involve network economics and scale for the cables and data centres. (Verizon, 2017; British Telecom, 2017). The third criterion; 'investments are characterized by a high level of physical specificity (i.e., have a high component of sunk investments)' is also met. As discussed in chapter 5 there is high asset specificity.

It is doubtful whether the submarine communication cable industry meets all three features of a utility as defined by Spiller. The industry is indeed characterized by high sunk costs, high physical specificity and economies of scale. However the first characteristic, 'the products are consumed widely' is only partly met. Also the second feature 'they exhibit important economies of scale and scope at the relevant levels of demand' is only partly met. Therefore firms that invest in submarine communication cables cannot by defined as pure utility companies. However the submarine communication cable industry has at least all three of the features to a certain extent. Therefor it is regarded that the transaction cost regulation can be used nonetheless to explain the regulations and relationship between the owners of submarine communication cables and countries. Large sunk costs, high physical specificity and economies of scale make it likely that the theory is helpful to explain the effect of government regulations on the firm investment behaviour to a country.

6.2.2 Basic concepts of the transaction cost regulation framework

"The transaction cost regulation (TCR), is a framework to analyse the interaction between governments and investors fundamentally, but not exclusively, in utility industries. TCR regards regulation as the governance structure of these interactions, and thus, as in standard transaction cost economics, it places emphasis in understanding the nature of the hazard inherent to these interactions"(Spiller, 2013, p. 232). Transaction cost regulation is an application of the TCE theory on the public/private interactions for regulation. The theory identifies two fundamental hazards which can arise. These two hazards are 'governmental opportunism' and 'third party opportunism' (Spiller, 2013). These two concepts are discussed next.

Governmental opportunism

´Governmental opportunism consists of the ability of governments to change the rules of the game via the standard use of governmental powers to extract the quasi-rents of utility investors´ (Spiller, 2013). The two determinants for possible governmental opportunism are the investment characteristics and the positive political theory. So which investment characteristics have an effect? According to Spiller: "high sunk investments and economies of scope increase the likelihood for governmental opportunism. The reason is that high sunk investments provide politicians with the opportunity to behave opportunistically vis-à-vis the investing company" In other words, sunk investments expose the utility to the risk of potential expropriation, which may be indirect and undertaken by subtle means"(Spiller, 2013, p. 235) According to Spiller the 'positive political theory' helps to explain the limits of opportunism. "The limits to governmental opportunism are institutional. The potential for the opportunistic use of legislative powers depends, to a large extent, on the control the executive may exercise over the legislature. Thus, a fragmented policy may provide more assurances to investors than a highly centralized government. Similarly, a judiciary with a tradition of independence may put some limits on opportunistic behaviour" (Spiller, 2013, p. 235). In this research the concept of governmental opportunism will be used to analyse the possible effects of government regulations on the future investments in submarine communication cables. Here, governmental opportunism does not have a negative connotation. The concept is simply used to discuss the effects of regulations on the investments to a country.

Governmental opportunism can have two important implications on the behaviour of the investors. The first implication is performance and "under investment will be the norm" (Spiller, 2013, p. 236). Another implication of governmental opportunism is that investors demand stricter regulation. "Facing the threat of governmental opportunism, utility investors would require particular safeguards to invest" (Spiller, 2013, p. 236).

<u>Third party opportunism</u>
"Third party investors can display opportunistic behaviour when there is a high probability of inherent informational asymmetries" (Spiller, 2013 p. 238). Since submarine communication infrastructure is very technical this might be applicable to submarine cables owners. The determinants for third party opportunism are different from the determinants of governmental opportunism. 'Third party opportunism does not depend on the existence of sunk investments. In fact, because the costs of third party opportunism are borne to a large extent by the political agent, and some extent by the investor … the potential for third party opportunism will depend, to a large extent, on the nature of the institutional environment in which the investment will take place. To thrive, third party opportunism requires some extent of political contestability and fragmentation"(Spiller, 2013, p. 238). In other the degree of third party opportunism depends for a large part on the structure institutional environment and the possibility of information asymmetries. The concept of third party opportunism is used in this research to understand and explain the behaviour of submarine cable owners and other users of the sea.

The implications of the third party opportunism are two folded. "The first implication is a negative performance of the regulated market. The added complexity required to limit the potential for third party opportunism will make regulation look as if marred by "red-tape," "conflict driven" and inefficient" overall"(Spiller, 2013, p. 240). The second implication is on regulation. "The exposure to third-party opportunism creates risks to both the public agent and the utility investors. In response, both will have incentives to formalize their relation (i.e., to move away from implicit agreements), and to make it highly specific)" (Spiller, 2013, p. 240)

6.2.3 Application of the theory

The transaction cost regulation will be applied to the interaction between submarine communication cable owners and the other users of the sea with the government of the Netherlands. A case study of the Netherlands will help to understand the effect of legislation on the investments in submarine communication cables. The case study is only focused on the Netherlands to increase the thoroughness of the analysis. In the first step of the analysis the legal environment of the Netherlands is discussed. Both the international and national legislation are described. Then based on industry documents, legal documents and interviews with different the investors, interest groups and public servants an analysis is made. The analysis focusses on the effects of the changing regulations and the spatial planning of the sea. Interviewees from both telecom providers and civil servants, such as Mr. Rea of BT and Mrs. Bots, regarded these interactions relevant.

6.3 Case-study: The effect of legislation on investments in submarine optic fibers in the Netherlands

6.3.1 Applicable legislation

<u>Laws on the sea</u>

The international applicable legislation for submarine communication cables is the United Nations Conventions on the Law of the Sea (UNCLOS). This convention "sets out the legal framework within which all activities in the oceans a seas must be carried out" and describes the lying and protection of submarine cables (United Nations, 2018). Like many other countries the Netherlands ratified UNCLOS (Overheid.nl, 1994). UNCLOS defines the right for investors to lay a submarine communication cable in international and territorial waters. However coastal states have the sovereignty that extends to their territorial sea. "Coastal States have the right to establish conditions for cables entering their territory or territorial sea … however beyond the limits of the 12 miles territorial sea, the coastal state may not (and should not) impede the laying or maintenance of cables" (United Nations, 2018). In the Netherlands the legislation regarding submarine communication cables in territories of the Netherlands is described in the Waterwet (Water law). The Waterwet is applicable for parties that 'intervene with the seabed'. The permit is issued by Rijkswaterstaat, a governmental agency. In principle a request for a water permit cannot be turned down under UNCLOS since the investor has the right to lay a cable. However additional requirements are in place for the issuing of a water permit. Therefore policymakers have discretionary space for the spatial planning of the North Sea. The Waterwet is quite general and non-specific and therefore a lot of policy comes from policy papers and priority policy papers (Duijts, 2017; Waterwet, 2009). An important policy paper is 'Beleidsnota Noordzee 2016-2021' which describes the structural spatial planning for the North Sea to the Exclusive Economic Zone of the Netherlands (Ministerie van Infrastructuur en Milieu, Ministerie van Economische Zaken, 2015). Together the Waterwet and policy documents describe the following requirements for a water permit:

- The investor must choose the optimal route in which there is little disturbance for other users of the sea (Duijts, 2017)
- Infrastructure of 'national interest', such as marine windfarms and gas infrastructure have priority over submarine optic infrastructure, since they are of 'national interest' (Ministerie van Infrastructuur en Milieu, 2012, p. 53) Submarine cables do not have this qualification.

In The projects of national interest have priority over the ones that do not have this qualification (Duijts, 2017; Waterwet, 2009)

- Shipping lanes should be crossed with a right angle. This is also in the interest of the owners of the cable. The repair operations of submarine cables in shipping lanes are very difficult (Duijts, 2017)
- In principle areas with special assigned function cannot be crossed. Examples of such areas are military practice areas, sand extraction areas. Only after permission of the parties of interest a cable can cross such an area (Duijts, 2017)
- For the purpose of efficient spatial use in the North Sea. Electricity cables, telecommunication cables and pipes will be bundled as much as possible (Ministerie van Infrastructuur en Milieu, Ministerie van Economische Zaken, 2015)
- Around submarine cables in the North Sea the government ensures a maintenance zone for the submarine cable owners of 500 meter on both sides where no sand winning activities are allowed. 'Research shows that for the construction of windfarms at sea in principle a maintenance zone of 500m around electricity cables is required. For telecommunication cables the maintenance zone is 750 meter'. However for efficient use of space the maintenance zones can be decreased, if possible. (Ministerie van Infrastructuur en Milieu, Ministerie van Economische Zaken, 2015) The reduction of the minimum maintenance zone was implemented in 2005.

<u>The concerned government institutions for permits</u>

A Water permit is not the only permit which is required for the complete construction of a new submarine communication cable. As showed in table 17 multiple governmental organisations are involved for the permits. The Waterboard and Rijkswaterstaat cooperate to create one permitting procedure for both the sea part and the terrestrial flood defence crossing part of the optic cable (Duijts, 2017). Furthermore permits of the Province and Municipalities might be required for the constructions on land. An overview of the involved institution is provided to sketch the institutional environment in which the governmental or third party opportunism can arise.

Table 17 - Governmental bodies which are involved with the construction and maintenance of submarine communication cables (Botman, 2017)

Involved institution	Function
Ministry of Infrastructure and Water Management	Is responsible for the management of the sea.
Rijkswaterstaat	Is the executing body of the Ministry of Infrastructure and Water Management, which issues the permits for cables in Dutch territorial waters. A permit for a new cable requires a working plan and an environmental impact assessment (Duijts, 2017)
Coastal guard	Is the monitoring and controlling body from the Ministry of Infrastructure and Water Management at sea. The coastal guard checks the safety requirements of submarine communication cables.

	However this institution mostly focusses on the shipping interest. (Duijts, 2017)
Ministry of Economic affairs and Climate Policy	Is responsible for policy regarding windfarms, both terrestrial and at sea
Netherlands Enterprise Agency (RVO)	Is the executing body of the Ministry of Economic affairs and Climate Policy. RVO guides the construction of new windfarms.
Water board	Is responsible for the dune areas that submarine communication cables cross after the landing at a beach. It is responsible for the permit to cross the dune areas
Province	Is the governmental body that issues permits for construction of the terrestrial part of a submarine communication cable part on the land of the province.
Municipalities	Is the governmental body that issues permits for construction of the terrestrial part of a submarine communication cable in the area of the municipality. Local municipalities also have to issue a permit for the construction work on the beach, which require mostly safety precautions (Duijts, 2017)

The next step of the analysis is to discuss whether the shift in the institutional environment, the national regulations and the characteristics of the investments creates either governmental opportunism or third party opportunism. This analysis is based on the interviews with both civil servants and investors, government documents and industry documents. These two effects can increase insight in how changes in legislation might influence the investment in submarine communication cables to the Netherlands. From this case study it can be determined if and how government legislation might influence investment behaviour.

6.3.2 Governmental opportunism

Constructions of submarine communication cables to a country require large investments. The high sunk costs and high asset specificity of the investments can create governmental opportunism (Spillers, 2012). Based on the interviews of the submarine communication cable owners and civil servants different type of possible governmental opportunism can be identified. These are; decreasing the maintenance zone, lack of protection of cables and difficulties to construct submarine cables in the future. These three types of governmental opportunism are discussed for the case of the Netherlands.

<u>Decreasing the maintenance zone in the territorial water</u>

The recommendation for safety (maintenance) zone of a submarine fibre is usually 750m on both sides of the cable. This is the industry standard, which is recommended by the International Cable Protection Committee (ICPC) and the European Subsea Cables Association (Fisk, 2017; British Telecom, 2017; ESCA, 2016). However in the policy paper 'North Sea 2016 – 2021' the minimum maintenance zone around submarine communication cables in Dutch seas were reduced below the 750m in certain cases. (Ministerie van Infrastructuur en Milieu, Ministerie van Economische Zaken, 2015). According to Mr. Duijts of Rijkswaterstaat this was done after consultation with KPN. For the construction of a windfarm at sea at the shore of Borssele the maintenance zones around the cables was reduced to under the 750m for the telecom cables 'Farland and SeaMeWe' (Staatscourant, 2016). According to the 'Kavelbesluit I Borselle' the effective space for maintenance is reduced to 600 meter at some places. The government believes that the likelihood of repair activities is low because there are no sensitive repeaters in this area. Furthermore fishing and large vessels, which are larger than 24 meters, are not anymore allowed in this area (Staatscourant, 2016)

However, according to British Telecom the reduction of the safety zone creates extra costs and increases uncertainty for British Telecom due to increased difficulties for cable maintenance and repair activities (British Telecom, 2017). Furthermore British Telecom argues that windfarm developers did not consult the telecom operators for the preparations and constructions of a new windfarm at sea that crosses their cable. "The focus of windfarm investors is to create as much windmills as possible to maximize electricity generation" (G. Rea, 2017). Other telecom operators have a similar opinion. In a reaction to the 'kavelbesluit I and II Borselle of the Dutch government, Deutsche Telekom AG, which acts on behalf of European Telecom Carriers in the cable consortium of the SEA-ME-WE-3, makes the same argument. The SEA-ME-WE-3 submarine telecom cable is one of the cables that was affected by the reduction of the maintenance zone. The consortium writes that: 'We herewith wish to kindly express our concerns that a limited to 500m safety zone around a submarine telecommunications cable will not allow the owner and operator to maintain their asset and repair it swift and properly in case of a failure. We know from the owner consortium's supplier ACMA (being the maintenance supplier of a number of submarine cable systems in the Atlantic) that they will refuse to operate in such small corridor. For general reasoning we would like refer to relevant publications such as the ICPC Recommendation No. 13, "The Proximity of Offshore Renewable Wind Energy Installations and Submarine Cable Infrastructure in National Waters"; The Crown Estate, "Submarine-cables-and-offshore-renewable-energy-installations PROXIMITY STUDY", Revision 5.0, 24.04.2012, by Red Penguin, Hampshire, England - to name a few". (Energieprojecten, 2015, p. 11)

However according to Mrs. Botman from the Energy and Innovation department of the Ministry of Economic Affairs and Climate policy it is not true that 500m is insufficient to repair and maintain submarine communication cables. She says that: 'According to the ESCA6 guidelines (the mutual agreements between submarine communication cable owners which determines the maintenance zone around cables) the free maintenance zone around a cable is 500m on both sides, therefore 1km in total … British Telecom demands 1.5km because they have contracts with older (and therefore cheaper) types of maintenance and repair ships which require more space' There is possibly a conflict between British Telecom and the owners of future new windfarms at sea in the Dutch territorial waters. British Telecom demands compensation of the government of the Netherlands for the extra maintenance costs due to the new windfarms at sea. British Telecom is dependent on the Netherlands for cable landings to the European continent.

Due to the high sunk costs of the investments in submarine communication infrastructure to the Netherlands British Telecom, Deutsche Telekom and the other telecom carriers can be regarded as 'locked-in' for the change in the legislation. Telecom providers could think that the Dutch government behaves opportunistically by changing the maintenance zones and not apply the international recommendations. However, on the other hand governments have the right to change the legislation based on democratic grounds. According to Spiller (2013) governmental opportunism might lead to underinvestment. This effect might be the case in the Netherlands. Mr. Rea of British Telecom indicates that: "The non-compliance of the guidelines creates extra costs because of increased maintenance costs. Also less optimal routes will have to be created through seabed which is less suitable; this increases the risks of a cable break and the construction costs. Longer routes also could increase the latency of the connection … If the Netherlands does not applying the international guidelines regarding submarine telecommunication cables there will be an impact in the future for the digital interconnectivity … British Telecom is not likely to lay new cables between the UK and Amsterdam if the guidelines are not applied." However it is not sure whether this will be reality. For example, British Telecom has pan-European network which has important links between the Netherlands and Great Britain (Rea, 2017). Due to the geographical location of the Netherlands as neighbor of Great Britain it would be very difficult to not land any cables in the Netherlands. In other words not applying the international guidelines is not likely to put off all new submarine cable investments to the Netherlands. However it could have a negative effect.

There could also be a positive effect of the reduced maintenance zone. The reduction of the minimum maintenance zones around cables might provide an incentive for cable owners to work more compact in the future.

<u>Lack of protection of the submarine telecom cables in the North Sea</u>

In the territorial waters of the Netherlands there are a large number of cable breaks due to fish nets and anchors of ships in combination with the shallow waters (KPN, 2017; Verizon, 2017; British Telecom, 2017) The reason for the high number of cable breaks is the high shipping and fishing activity in combination with the shallow waters which make the cables vulnerable. (Fisk, 2017) According to KPN a lot of fishers are active around the submarine cables. KPN monitors the location and speed of the boats of fishers to prevent damage to the cables. If a fisher is stalled within the maintenance zone of the cable the coastal guard is signed in to prevent damage to the cable (KPN, 2017). British Telecom also has installed a monitoring system. According to some telecom operators the Dutch national government does not optimally protect the submarine communication cables. Safety zones around submarine cables are not respected by fishers (Dinkelman, 2017). A high number of cable failures will decrease the likelihood that a future cable will be deployed in the area (Palmer-Felgate & Booi, 2016). Better protections of submarine cables are likely to have a positive effect on future investments.

Difficulties to construct submarine cables to the Netherlands in the future

New windfarms at sea close to the coast of the Netherlands could reduce the possibility for new submarine communication cables in the future (KPN, 2017; Verizon, 2017; Facebook, 2017; British Telecom, 2017) The windfarms make that the only suitable route for submarine communication cables to Amsterdam are cut off (British Telecom, 2017) Figure 21 shows the current and the future infrastructure in the North Sea. The green non-dotted-areas are planned areas for future windfarms at sea. The dark purple areas are existing windfarms at sea. According to Mr. Duijts from Rijkswaterstaat, a government agency, windfarms without a special cable corridor cannot be crossed by new submarine telecommunication cables. Existing windfarms at sea are therefore a barrier for future cables and will force future submarine optic cables in the direction of Amsterdam to the shipping lanes. The routes of the cables will also have to be longer and more vulnerable.

The 'Wadden Sea', the sea in the north of the Netherlands is a protected nature area. However it can be crossed (Duijts, 2017). This sea is also a natural barrier for submarine telecommunication cables. The strong tides in this area have a cost increasing effect on submarine communication cables (Duijts, 2017). Cables have to be placed up to three meters below the seabed, which is much deeper than usually is required. Therefore it is much more expensive to lay a cable in this area. On the north side of the Netherlands there is also a maritime army training area. However crossing this area is possible if this is negotiated with the government. (Duijts, 2017). Figure 21 displays all the different areas in the seas around the Netherlands.

According Mr. Duijts of Rijkswaterstaat on option for the national government of the Netherlands is to change the spatial planning of the North Sea. The current allocation of infrastructure in the (North) sea is mostly based on a 'first come, first served' basis. This creates strange garlands' in the submarine cable infrastructure. The government acknowledges that digital infrastructure is important, but at the same time it creates barriers for future new cables. Perhaps the government should force the users of the sea to collaborate in the North Sea. The North Sea is getting more and busier, which requires a more structured approach (Duijts, 2017). From the perspective of the submarine cable operators the absence of structure to allocate space in the sea can be perceived as governmental opportunism. New barriers, such as windfarms at sea, could block required new connections in their network. The reduced accessibility and current spatial planning can therefore have a negative effect on the future investments in submarine communication cables to the Netherlands.

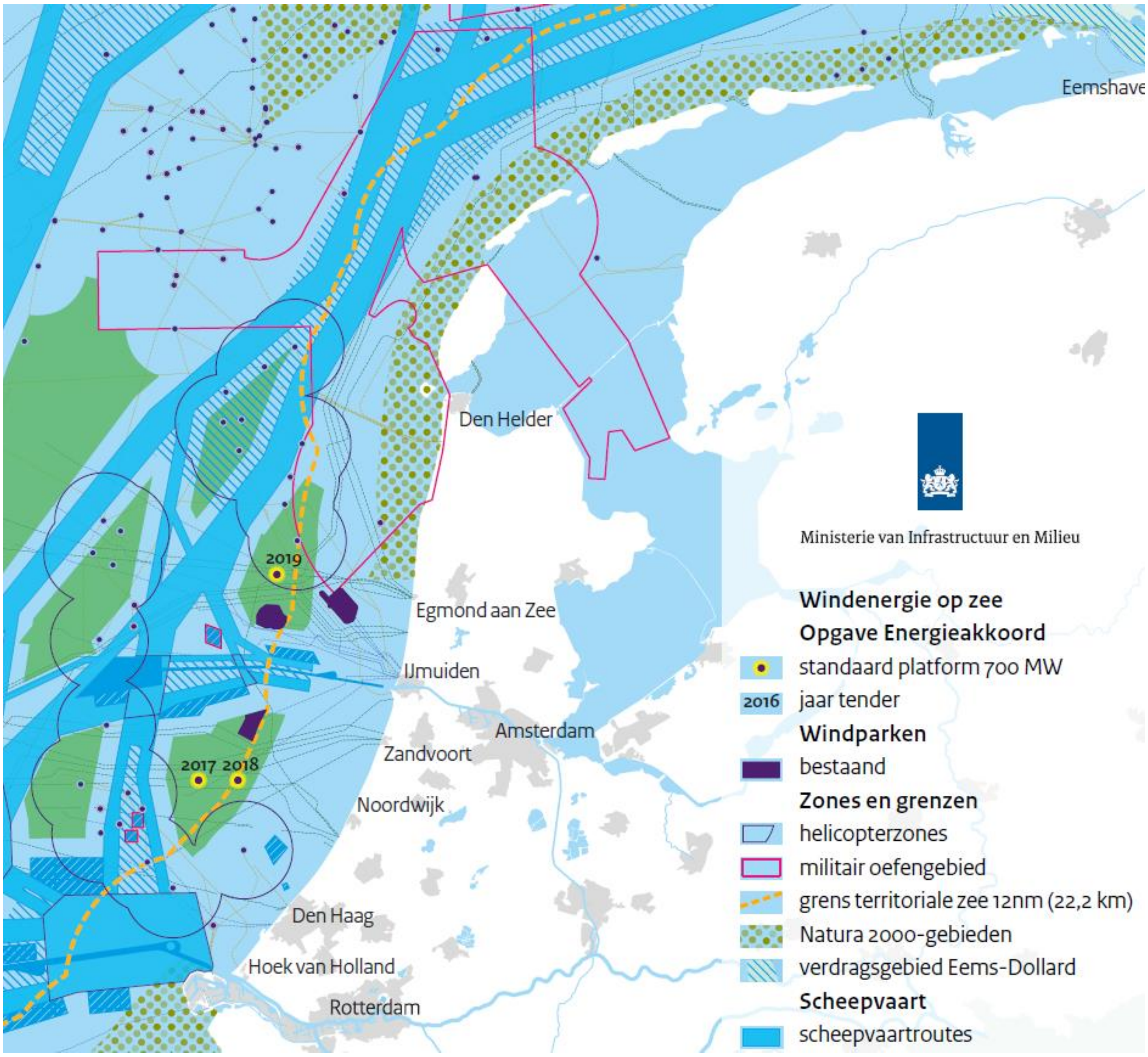


Figure 21 - Interactive map Noordzeeloket 2017 (Ministry of Infrastructure and Environment, 2017)

6.3.3 Third party opportunism

As discussed in 6.2.1 the third party investors can display opportunistic behaviour when there is a high probability of inherent informational asymmetries. (Spiller, 2013) "Third party opportunism will depend, to a large extent, on the nature of the institutional environment in which the investment will take place. To thrive, third party opportunism requires some extent of political contestability and fragmentation"(Spiller, 2013, p. 239). In paragraph 6.3.3 possible third party opportunism is discussed. It discusses the information asymmetry about the required maintenance zone.

<u>Information asymmetry about the required safety (maintenance) zone</u>

The Dutch Ministry of Economic affairs and Climate policy disagrees with some telecom operators about the required maintenance zones around submarine cables. (Botman, 2017) According to British Telecom the required space is at least 750m on both sides of the cable. Mrs. Botman of the

Dutch Ministry of Economic affairs and Climate policy however argues that the required maintenance zone is 580m, based on the ESCA Windfarm Proximity guidelines in shallow waters (Ministry of Economic Affairs, 2017; ESCA, 2016). Since the telecom carriers only have the precise technical information about the required space there can exist information asymmetry. The information asymmetry could create distrust and might lead to legal actions. According to Mr. Vermeulen of the Ministry of Economic Affairs and Climate Policy British Telecom demands financial compensation of windfarms owners and the government for new windfarms in some cases (Vermeulen, 2017). "An example of this is the construction of a windfarm in Germany where British Telecom received financial compensation of windfarm at sea owners"(Vermeulen, 2017). This was possible because a cable proximity agreement (CPA) is compulsory in Germany. A compulsory CPA forces investors in windfarms at sea to have an agreement with owners of 'crossing infrastructure'. In this way submarine infrastructure owners can force financial compensation from windfarm owners. From the perspective of the government of a government this might be defined as third party opportunism. Submarine cable owners might behave opportunistically by blocking the construction of new windfarms to have financial gains. In this way a CPO could create conflicts.

As stated by Spiller the third party opportunism might add complexity to the regulation and could create 'conflict-driven-regulation'. The high technological complexity of the submarine communication industry makes it difficult to balance the interest between the interest of submarine communication cables and other infrastructure at sea.

6.3.4 Overview of the transaction cost regulation analysis

In the case study of the regulation of the Netherlands different types of possible opportunistic behavior of both the government and third parties were identified. Due to the high sunk investments of submarine communication cable owners there is a risk for governmental opportunism. The government of the Netherlands reduced the maintenance zone without consulting all the cable owners according to Mr. Rea of British Telecom. According to him British Telecom was surprised of the construction of windfarms at sea which reduced the maintenance zone. This might be perceived as governmental opportunism by the cable owners; however this is not necessarily the case. Governments have the right to change the law.

Another problem for cable owners is the high number of cable cuts in the Dutch sea. This leads to the investments in monitoring systems by telecom operators such as KPN and British telecom. These companies might perceive the lack of cable protection as opportunism. Another form of possible government opportunism is the creation of artificial barriers for future cables. Future windfarms at sea might block routes for future submarine cables. Since the telecommunication cables are not referred to as of 'national interest', they have lower priority than the energy infrastructure (Ministerie van Infrastructuur en Milieu, 2012, p. 53) According to Spiller (2013) the governmental opportunism will create high transaction costs of regulation. This could result in higher uncertainty and lower investments in submarine optic fibers to the Netherlands in the future. However the reduction of space could also be an incentive for cable owners to start to work more compact.

From the perspective of the Dutch government possible third party opportunism might occur. Telecom operators such as British Telecom demand financial compensation for the more shallow maintenance zones. Due to information asymmetry it is difficult for the government to exactly determine the minimum maintenance zone. This could create third party opportunism by cable owners, which could exaggerate the required space for their cables.

6.4 Transaction cost regulation factors for the comparative case study

The case study of the Netherlands showed that national regulations and especially governmental opportunism can have an impact on decisions of the future investments in submarine communication cables to a country. The next step is to formulate the findings of the case study as factors for the explorative model of chapter 7. The geographical and legislative conditions of the Netherlands are likely to be different from other countries. However nonetheless an attempt is made to take the lessons from the case study and translate these into factors for the comparative case study. In the analysis three types of legislative issues were discussed.

These issues are:

1. The reduction of the maintenance zone in the territorial water
2. Insufficient protection of the submarine telecom cables in the North Sea according to the cable owners
3. Difficulties to construct submarine cables to the Netherlands in the future

The lack of sufficient space for maintenance and new cables might have a negative effect on the investments. In seas with high density of activity legislation has to structure the spatial planning so that enough space is created and sustained for submarine cables in a not vulnerable route. Therefore the first of the two transaction cost regulation factor for the chapter 7 is:

- Is there enough space available for the maintenance of the current submarine infrastructure and is there a possibility to invest in new cables to the country? Is this regulated structurally and in compliance with the industry standards? (If this not the case submarine telecom cables investors could be less inclined to (re)invest to this country)

The second issues were the lack of protection of the submarine telecom cables in the North Sea. Especially a combination of shallow waters and intensive shipping and trawl fishing activities increases the likelihood of costly cable cuts for submarine telecom cable owners and operators. A lack of protection against other users of the sea decreases the likelihood of future investments.

- Is there a place where submarine cable can land easily and is there legislation that protects the submarine telecom cables from other users of the sea?

6.5 Reflection on the application of transaction cost regulation theory

The transaction cost regulation theory was applied to analyze the effects of the government regulations of the Netherlands on the investment decisions. The transaction cost regulation states that in (utility) industries with high sunk costs and high asset specificity it is likely that governmental opportunism will occur. Although the submarine optic fiber industry does not meet completely all the features of a utility the TCR framework was applied. It turns out that in the case of the Netherlands indeed different types of opportunism could be identified based on the theory. In this way the relation between legislation and investments in submarine cables could be described. The transaction cost regulation theory provided in this way insight in the effect of government action on the investments. Opportunism as defined in this chapter however does not necessarily need to be negative for a country. Governments have the right to change the law on a democratic basis.

Like the transaction cost theory, the transaction cost regulation theory is a very broad theory and therefore it is easy applicable. The theory generated interesting insights in the possible consequences of governmental legislation. The flexibility of the theory is also the largest downside of the theory. Legislation and policies of the government can be fairly easily defined as governmental opportunism. Changes in legislation will most of the times effect firms which have sunk costs. However should not always be identified as governmental opportunism. Governments have the right to change the law within boundaries and therefore there will always be discussion. Another weak point of the theory is the poor generalizability. There are large differences in the 'rules of the games' in different countries. Since the theory was applied to only the Netherlands it remains unknown if the described effects of legislation are also important in other countries. The described legislative effects describe the spatial planning and the protection of the cables. However it easy to imagine that in third world countries corruption and hard permit processes might be the main issue in terms of governmental opportunism. Therefore the factors for the explanatory model from this chapter should only be used to understand the investments to comparable countries. Other institutional environments could have other sorts of third party and governmental opportunism.

Chapter 7: Case studies of the Netherlands and Spain, an initial validation of explanatory model

In the chapter 7, the synthesis, the factors that were identified in chapter 4, 5 and 6 are combined to an explanatory model to analyze the investments of submarine communication cables in a country. Then this experimental model is applied compare the investments in submarine telecom cable to the Netherlands and Spain. By applying the explanatory model to compare two countries an initial validation of the factors in the model can be validated and discussed.

7.1 Structure of the chapter

The first step in the synthesis chapter is to explain how the identified factors from the analysis chapters are constructed to the explanatory model. This is discussed in paragraph 7.2. Then, in the next step in paragraph 7.3 factors form chapter 4, 5 and 6 are translated into analyzable factors and are listed. Subsequently the explanatory model is put into practice for the first time by comparing the investments to the Netherlands and Spain in paragraph 7. In paragraph 7.5 the investment behavior of companies to the Netherlands and Spain are compared based on the comparative qualitative study. This is the first validation of the exploring model. Does de explanatory model address the right factors to explain the investments to these countries? Subsequently in 7.6 the construction of the model is discussed from a scientific perspective. How can it be improved and can it be used for future research?

7.2 The first step to create an explanatory model

The issues that were identified based on the resource-based view, transaction cost theory and transaction cost theory from respectively chapter 4, 5 and 6 are translated into factors for a step to create an explanatory model for the cable investments to a country. The first step is to formulate the issues from chapter 4, 5, and 6 as factors for the model. For every criterion it is also indicated whether the criterion can be influenced directly by the government or not. In this way the model can be used to evaluate the policy recommendations. After that all the factors are listed and combined. The next step is to fill in the different factors based on the industry documents and the interviews to compare the Netherlands and Spain. In this way an overview is created to compare different countries. The explanatory model then can be used to contrast the two countries on the factors from the analysis. In this way differences in investments in submarine communication cables to these countries can be understood.

7.3 The creation of a the explanatory model for the comparison of countries

The factors that were identified to have an effect on the investment behavior in submarine communication cables have been placed in table 18. Factors which were two times in the list were deleted. The identified factors then were given a name for in the list.. Lastly the factors are classified as 'can be influenced' or 'cannot be influenced' by government. In other words can or cannot the government of a country have direct influence on to a certain criteria. This distinction is useful for the policy recommendations for governments.

Table 18 - Translation from identified factors of influence for the qualitative comparative study

Identified factor that has influence on the investment in submarine communication cables to a country	Name of the factor	Influence of the government
Size of (digital) economic center in the region?	Digital economic centers	Cannot be influenced
Are there reachable backhaul connections and landings station available close to the shore?	Number of landing stations	Cannot be influenced
Do current telecom operators have to amortize their cable in the short term?	Number of cables that are older than 2003	Cannot be influenced
What is the ratio of between supply and demand of transit data?	Non-used supply	Cannot be influenced
What is the number of submarine communication cables that land already in the country?	Number of landing cables	Cannot be influenced
Are their datacenters (CDNs) of content and application providers in the country?	Number of CDNs of CAPs	Cannot be influenced
Are there terrestrial backhaul connections which directly connect to the datacenters?	Quality of terrestrial backhaul	Cannot be influenced
Do the content and application providers have already an own cable to the country/region?	Number cables owned by CAPs	Cannot be influenced
What are the prices of existing submarine optic fibers that connect to the country?	Price level of data transit	Cannot be influenced
Does a cable to the country create more diversity in the network of the content and application provider?	Increase in diversity of existing networks	Cannot be influenced
Does the country have a beneficial geographical location?	Geographical location	Cannot be influenced
Is there enough space available for the maintenance of the current submarine infrastructure in the territorial waters of the country and is this regulated in compliance with the industry standards?	Guaranteed maintenance zone	Can be influenced
Is there a possibility to invest in new cables to the country and is this regulated?	(Regulated) space for future cables	Can be influenced
Is there legislation that protects the submarine telecom cables from other users of the sea? (Can actors that damage cables can be held liable for the costs involved?	Degree of cable protection	Can be influenced
What are the risks of cable failure of a cable to the country?	Risk of cable failures	Can be influenced
Will there be in the near future a construction of a new (submarine electricity) cable by a government organization?	Government investment	Can be influenced
Is the submarine fiber market liberalized?	Liberalization	Can be influenced

The next step is to create the final explanatory model for analysis. The model is divided between the factors that can be influenced and that cannot (or only indirectly) be influenced by a government. According to Mrs Violari of Facebook the company has the following list of priorities. '1. The new cable should add diversity to the infrastructure network of Facebook to increase the reliability of the network (primary goal) 2. The new cable should increase availability of capacity to meet the growing capacity demand. 3. The new cable should be connected easily to (terrestrial) backhaul connections so that content delivery networks and datacenters can be reached effectively 4. The ease of obtaining landing permits 5. Landscape characteristics of the country are evaluated. Shallow waters, heavy fishing areas, windfarms and places with already a large number of submarine cables will try to be avoided' (Violari, 2017) In other words the demand factors are more important than the hurdles of the legislation and environment. Table 19 shows the final list of factors that can be used to compare the Netherlands and Spain.

Table 19 - Framework to compare the investment behavior in submarine telecom cables between countries

Name of the criterion	Discusses in paragraph
Price level of data transit	7.4.1
Number cables owned by CAPs	7.4.2
Non-used supply	7.4.3
Digital economic centers	7.4.4
Number of CDNs of CAPs	7.4.5
Increase in diversity of existing networks	7.4.6
Quality of terrestrial backhaul	7.4.7
Number of landing cables	7.4.8
Number of cables that were constructed before 2003	7.4.9
Geographical location	7.4.10
Liberalization	7.4.11
Risk of cable failures	7.4.12
(Regulated) space for future cables	7.4.13
Degree of cable protection	7.4.14
Guaranteed maintenance zone	7.4.15
Government investment	7.4.16

7.4 Comparing the Netherlands and Spain

In paragraph 7.4 the comparison between the Netherlands and Spain is made based on the factors in table 20. Systematically the two countries are compared based on the factors. It also discussed what the effect is of the differences in the factors on the firm behavior of investments in submarine communication cables to that country.

7.4.1. Price level of data transit

The Netherlands / Spain: According to Mr. Booi of Verizon, the west-European data transit market functions as one (Booi. de, 2017 The lease costs for and therefore the costs for data transit are low in this entire area. Therefore the price level of data transit to both the Netherlands and

Spain are considered low. The price level of data transit will therefore not make a difference in the investment behavior to both countries.

7.4.2. Number of cables owned by CAPs

Netherlands: The number of cables that are owned by content and application providers that land in Spain is one (TeleGeography, 2017). This one cable is the MAREA cable in which both Facebook and Microsoft invested (Microsoft, 2017). These companies will not invest in another cable to Spain.

Spain: The content and application providers do not own a cable that lands in the Netherlands (TeleGeography, 2017). However Microsoft invested in AEConnect (AEC) and the GTT express which both land in Ireland (TeleGeography, 2017). From here the company can interconnect easily to the Netherlands through the UK.

7.4.3. Non-used capacity of cables

The Netherlands: About 80% of fibers of the six cables between the Netherlands and the UK are not used. This is why this is practically a 'buyer's market' (Booi. de, 2017) Also on the trans-Atlantic market there is overcapacity. Especially since the three new cables; the Hibernia Express, AquaComms and Marea (Booi. de, 2017). Therefore it can be said that there is high non-used capacity of submarine telecom cables.

Spain: For Spain there is the same situation regarding the trans-Atlantic submarine capacity. As stated earlier the west-European transit market can be seen as one. Therefore the non-used capacity which is described for the Netherlands can also be used by companies in Spain. Therefore the non-used capacity of submarine cables is also considered high.

7.4.4. The digital economic center

Netherlands: In the Netherlands two of the largest internet exchanges of the world are located. These are the AMS-IX and the NL-IX which have respectively an average throughput of 3,339 GB/s and 1,770GB/s in 2016. (AMS-IX, 2016) (NL-IX, 2016). Gavin Rea of British telecom also acknowledges the importance of the Netherlands and more specifically Amsterdam. According Mr. Rea: 'The links to Amsterdam (from the UK) also recognize the economic and financial importance of Amsterdam.' Therefore the Netherlands is relevant as digital and economic center. This could pull new investments.

Spain: In Madrid a part of the servers of the DE-CIX are located. This is a very large internet exchange which has an average throughput of 4,004 GB/s in 2017 (DE-CIX, 2018). Spain is also an important node for traffic to the middle-east (TeleGeography, 2017). The relevancy of the digital economic center is determined as a bit lower.

7.4.5. Number of CDNs of CAPs

Netherlands: Google has invested 600 million euro in a new data center in the Eemshaven, the Netherlands. (Google, 2018). Microsoft also has two databases for their Azure cloud services in the Netherlands. (Microsoft, 2018). Therefore there are two databases of the large content and application providers in the Netherlands. This could be an factor for CAPs to invest in a new cable to the Netherlands.

Spain: None of the CAPs have datacenters in Spain (Analysys Mason, 2018). Therefore this will not be a factor which will attract new cable investments.

7.4.6 Increase in diversity of existing networks

The Netherlands: Telecom operators and content and application providers cannot add additional diversity by connecting the Netherlands with a new cable. There are already a large number of cables between the Netherlands and the United States through the UK. (TeleGeography, 2017). Therefore the increase in diversity of existing networks is determined as low for the Netherlands. This means that this factor is rewarded as low for future cables.

Spain: There are very few direct connections between the Spain and the United states (TeleGeography, 2017). Therefore the MAREA cable brought extra diversity to the networks of both Microsoft and Facebook (Crowley, 2017; Violari, 2017) The Columbus-III between Spain and the United States adds also diversity to the trans-Atlantic connections. Therefore this factor is highly important for firms that invest in a new cable to Spain.

7.4.7 Quality of the terrestrial backhaul

The Netherlands: The Netherlands has a very fine-meshed high quality terrestrial backhaul network. The terrestrial backhaul is available on most places very close to the coast. Therefore the quality of the terrestrial backhaul network the Netherlands is determined as high quality (ITU, 2018). This could attract new investments. However, the high quality terrestrial backhauls could make direct cable landing also less necessary because the terrestrial backhaul can be used.

Spain: The backhaul of Spain is a bit coarser than in the Netherlands. This is logical since the surface of Spain is much larger. Terrestrial backhauls are nearly everywhere available close to the coast as well (ITU, 2018). The quality of the terrestrial backhaul is mostly similar. Therefore there is not a large different between the Netherlands and Spain based on this factor.

7.4.8 Number of cable landings

The Netherlands: There are seven places where submarine communication cables land. (TeleGeography, 2017). This is important to attract new cables.

Spain: There are eight places where submarine communication cables land. One of them is in the North close to Bilbao, three of them are on the east coast and the remaining landing places are in the south in the area of Gibraltar (TeleGeography, 2017).

7.4.9 Number of cable that were constructed before 2003

The Netherlands: Eleven of the twelve cables that land in the Netherlands were constructed before 2003. (TeleGeography, 2017) The only cable which was constructed in recent years is the COBRA-cable of Relined. It is likely that some of these cables will be renewed, which increases the chance for future submarine investments.

Spain: Eight of the sixteen submarine communication cables that land in Spain were constructed before the year 2003. (TeleGeography, 2017)

7.4.10 Geographical location

The Netherlands: The geographical position of the Netherlands is good for trans-Atlantic cables which crossed the United Kingdom. Therefore several submarine cables are constructed between the United Kingdom and the Netherlands. However these cables have to compete with the submarine cables that cross the canal tunnel between France and the United Kingdom (TeleGeography, 2017) (G. Rea, 2017) However for direct trans-Atlantic cables the Netherlands is not the most ideal located behind the United Kingdom.

Spain: is located on the Iberian Peninsula and has the shortest route between the South of Europe and the United States. Furthermore Spain is located along the Mediterranean Sea, which makes it also a landing country for countries to the middle-east (de Booi, 2017). The south west of Spain is also a good connection point for direct cables between South America, Africa and Europe. Spain is rated with high because of the several cable options for intercontinental cables.

7.4.11 Liberalization of the transit market

The Netherlands /Spain: Both countries have a liberalized market (Personal message from Mr. Oteo of MINETAD, 2017; United Nations, 2013). This is an important condition for investments in submarine communication cables by firms.

7.4.12 Risk of cable failure

The Netherlands: According to Mr. Dinkelman and van der Paard of KPN and de Booi of Verizon the risk of cable failure are large for cable that land in the Netherlands. This is because of the risks that are involved with shallow waters. Between 2008 and 2014 there were ten cable cuts in exclusive economic zone of the Netherlands and one in the territorial waters of the Netherlands. (Booi. de. 2017) For this reason most telecommunication providers in the Netherlands use the channel tunnel between France and the UK (Rea, 2017; Fisk, 2017; Booi. de, 2017. The risk of cable failure in the North-sea is qualified high. This could have a negative effect on the future investments in submarine communication cables. However the government can reduce the risk.

Spain: The risk of cable failure to Spain is much lower. According to Mr. Crowley of Microsoft: "A connection to Spain/Portugal has a potential for reduced risk for external human cable aggression because of deep sea (small continental shelf) in comparison with the extensive shelf seas and shallower waters of the North of Europe". Therefore the risk of cable failure is determined lower than the Netherlands. In regard to the risk of cable failure Spain is more attractive for new cables investments than the Netherlands.

7.4.13 (Regulated) space for future cables

The Netherlands: As discussed in paragraph 6.3.2 there the space which is available in the territorial seas of the Netherlands is decreasing. One of the reasons is the construction of new windfarms at sea which forms a barrier for future cables. The 'Structuur visie ruimte en milieu' (Ministerie van Infrastructuur en Milieu, 2012, p. 53) indicates that infrastructure such as energy infrastructure is of 'national interest'. This implicates that windfarms at sea and other energy-related infrastructure has priority over the submarine communication cables (Duijts, 2017; Waterwet, 2009). Therefore the variable space for future cables is determined as low. This could have an negative effect on the investments to the Netherlands.

Spain: Spain has a very extensive coast with a lot of possible routes for cables (TeleGeography, 2017). Therefore the space for future cable is determined as high. The availability of space for cables could have a positive effect in investments to Spain.

7.4.14 Degree of cable protection

The Netherlands: The submarine optic fibres are well protected by legislation. Any harm to cable done by fishers has to be refunded to the cable owners. This was acknowledged by judges in court cases (Duijts, 2017). Rijkswaterstaat, a public agency, tries to mediate between fishers and submarine cable owners. Fishers can notify any loose cables on the surface, so that cable owners can bury the cable again. (Duijts, 2017) The degree of cable protection is therefore regarded as high.

Spain: Spain also ratified UNCLOS (United Nations, 2013). Therefore the degree of cable protection of Spain is determined high. However more research is required for the detailed legal situation.

7.4.15 Guaranteed maintenance zone

The Netherlands: As discussed in the paragraph 6.3.2 the maintenance zones for submarine communication cables in Dutch territorial waters was reduced from 750m to 500m in cases of a lack of space. Therefore the international standard for not guaranteed in the Netherlands. This could have a negative effect on the submarine cable investments.

Spain: Maintenance zones in Spain are much less an issue since there is much more space available due to the differences in geography (TeleGeography, 2017).

7.4.16 Government investments

The Netherlands: In the last years the Dutch national government directly invested in a submarine communication cable between the Netherlands and Denmark (Relined, 2017).

However according to Mrs. Weijers of Relined there are no future plans for cable investments by Relined. Therefore the government investments are characterized as low.

Spain: The CNMC, the Spanish independent market regulator, regulates the price of the services of Telefonica over ten submarine communication cables. These cables are regulated because they are the only connection for the islands. The cables are; Cádiz – Ceuta; Málaga – Melilla; Península – Canarias; Gran Canaria – Fuerteventura; Gran Canaria – Lanzarote; Tenerife – La Palma; Tenerife – La Gomera; Hierro – La Gomera; Mallorca – Menorca and Ibiza – Formentera (CNMC, 2013). Most of these cables connect islands in the Spanish territory. However in recent years more and more cables are deregulated. An example is the cable between the Peninsula of Spain and the Canary Islands (CNMC, 2018). Therefore the government investments of Spain are also regarded low.

7.5 A comparison of the Netherlands and Spain, validation of the identified factors

Table 20 provides and overview of the differences that were found between the Netherlands and Spain in regard to the factors that are important for submarine communication cable investments. The table shows a substantial amount of differences between the investment behaviour to these countries. The comparison between the Netherlands and Spain with the use of the factor of the explanatory model provides an opportunity to do an initial validation of the identified factors in this study. To what extend can the scorecard explain the investments in submarine cables to these countries? By comparing the scorecard with the actual submarine connections to these countries the relevancy can also be discussed. First the outcomes of the qualitative comparative analysis are discussed. Secondly the discussion of the validation is executed and lastly relative importance of the explanatory factors is discussed.

7.5.1 Comparative qualitative study of the Netherlands and Spain

Table 20 displays the comparison of Spain and the Netherlands. The table provides an overview of the rating of the Netherlands and Spain based on the factors that were identified in the research. The focus will be on the factors with large differences between the two countries, since these are expected to explain the differences in investments to both countries. The first factor with different values is 'number of cables owned by CAPs'. Spain already has one landing of a cable that is owned by CAPs, the Netherlands has none. The expectation is that this will make the Netherlands a bit more attractive than Spain for future investments of CAPs. 'Non-used supply' is different between the Netherlands and Spain. There is high non-used supply towards the Netherlands and medium for Spain. The existence of non-used supply is expected to lower the chance for new investments, since parties can already buy existing capacity on the market. The factor 'digital economic centres' is different. The Netherlands is valued a bit higher than Spain. Higher economic activity can attract more cables. A large difference between are the amount of CDNs of CAPs. CDNs will require sufficiently connectivity for CAPs to these servers. Spain scores much better in the scorecard on the 'increase in diversity of exiting networks' criterion. Currently there are already a lot of cables between the United States and the North of Europe. A cable to the South of Europe increases the diversity of the networks.

Table 20 - Overview of qualitative comparative analysis between the Netherlands and Spain

Name of the factor	The Netherlands	Spain
Factor that cannot be influenced by governments		
Price level of data transit	Low prices	Low prices
Number cables owned by CAPs	No cables of CAPs land in the Netherlands	There is one cable of CAPs, which is the MAREA cable
Non-used supply	There is a lot of non-used supply both in the North-Sea and Transatlantic	There are fewer connections between the south of Europe and the Americas
Digital economic centers	High demand for data transit	There is a medium demand in Spain
Number of CDNs of CAPs	Three CAPs invested lately in datacentres in the Netherlands	No datacentres are located in Spain
Increase in diversity of existing networks	Low, there are already a lot of cables in the North of Europe	High, there are few cables between the American continent and the South of Europe
Quality of terrestrial backhaul	High quality fine-meshed network	Medium quality network, which is a bit more coarse
Number of landing cables	There are seven cable landing locations	There are eight cable landing locations
Number of cables that were constructed before 2003	Eleven cables were constructed before 2003	Eight cables were constructed before 2003
Geographical location	The country is 'hidden' behind Great Britain. Therefore it is less attractive for direct transatlantic cables. However the Netherlands is useful as 'gate' to the mainland of Europe	The location of Spain is good for cables from Africa, middle-East and transatlantic cables
Factors that can be influenced by governments		
Liberalization of the telecom market	The market is liberalized	The market is liberalized
Risk of cable failures	Due to the shallow waters and intensive use of the sea there is a high risk of cable failure for cables to the Netherlands	There is a relatively low risk for cable failure to the Netherlands because of the deep waters and large waters
(Regulated) space for future cables	Because of the construction of windfarms at sea, sand mining and protected areas there is little space for new cables	Due to the deep sea and size of the country there is enough space for future cables
Degree of cable protection	Cables are protected	Cables are protected

Guaranteed maintenance zone	The maintenance zone around submarine cables was reduced from 750m to 500m in some cases	--
Government investment	There is low government investment. The only public cable to the main land of the Netherlands is the COBRA cable of Relined, a public enterprise	There are ten cables that are regulated by the CNMC to the Islands. Spain does not invest in new public cables

A factor that is valued very differently for Spain and the Netherlands is 'risk of cable failure'. As discussed in paragraph 7.4.12 the shallow seas and high fishing and shipping activity in the Netherlands increase risks of cables failures. On the contrary Spain has wide deep seas which have much lower risks for cable cuts. Therefore these are valuated very differently. This is also the case for space for future cables. As said in the Netherlands there is little space for new infrastructure due to the high number of users of the sea. In Spain this is not the case since it has vast coastal waters.

7.5.2 Validation of the explanatory model

The next step is to discuss to what factors of the explanatory model can explain the investments in submarine communication cables to a country. In the scorecard most of the relevant factors from the interviews from paragraph 3.3.3 are discussed. In general we can say that the model gives an overview relevant factors which are helpful to understand investments to a country. However it is not possible to provide a hard validation with the explanatory, since the outcome of the model itself is partly based on the outcomes of the interviews. The differences in the previous part of 7.5 showed that the factors are capable of identifying the differences between countries that can explain the differences investments in cables. Furthermore the outcomes of the scorecard provide an image which is in line with the investments in cables to these countries. Examples of factors which are not yet discussed in by the explanatory model are the influence of tax and corruption in a country. Also extra factors should be added that discuss the influence of other type of government regulations. The current regulatory factors are only based on the case study of the Netherlands. On the other hand it is not possible to add all factors which influence the investment behaviour in submarine communication cables. This would create an infinite list of factors. In general it is concluded that the scorecard is a helpful initial approach to compare the investment behaviour of companies to countries. However this first version of the model should be applied to more countries for further validation.

7.5.3 Discussion of the relative importance of the factors

By comparing the outcome of the comparative analysis with the current cables that land in the Netherlands and Spain insight can be created about the relative importance of the different factors. 'Liberalization of the telecom market' is the most important factor, because it is not possible to construct cables to countries that do not allow cable landings. However for the other factors a distinction will be made between the CDNs and Telecom operators, since they have different preferences.

Relative importance of the factors for the telecom operators

For the telecom operators it is likely that the most important factors are 'price levels of transit data', 'non-used supply' and the 'importance of the digital economic centre'. Since most telecom operators focus on the direct sales of connectivity they will be focused on connection areas with high transit data demand. However this is profitable if the price levels of transit data are sufficiently high. Therefore these two factors are expected to have the highest relative importance. The second most important factors are expected to be 'availability of landing stations' and the 'risk of cable failure'. Telecom carriers want to have easy access and want to have the lowest possible risks of cable failure, since cable cuts are expensive.

Relative importance of the factors for the application providers

The content and application providers have different relative weights for the factors that explain their investment behaviour. As discussed earlier the CAPs invest as part of a vertical integration strategy. Therefore they will be more interested in the 'number of CDN of CAPs' in a country and the 'increase in diversity of the network'. The strategy of CAPs is to invest in new routes between their datacentres that can reduce the risks of their supply chain. The second important factor is 'quality of the backhaul network'. If the quality of the backhaul network is high CAPs will choose a route with a very low risk for cable cuts which adds diversity, such as the MAREA cable (Violari, 2017; Crowley, 2017)

The other factors such as government regulations which determine the maintenance zone are relevant, but they are not the most important factors that determine the investments strategies of companies.

7.6 Scientific reflection on development and application of the explanatory model for firm investments in submarine communication cables

Paragraph 7.6 provides an overview of the scientific reflections of the development and application of the explanatory model. This reflection is based on the scientific reflections in the end of chapters 3, 4, 5 and 6 and this chapter.

In chapter 3 the theories were chosen based on the relevant factors that were identified from the interviews with the stakeholders. Three theories were chosen, which are; resource-based view, transaction cost theory and transaction cost regulation theory. It was expected that the three theories could be used complementary to each other under the assumption of pluriformity. Porter's five forces theory was rejected since it assumed holism, which is not suitable to analyse the submarine communication industry. The multi-sided platform market theory was not added to the framework because it was not expected to have any additional benefit to the analysis. It can only be used to understand the business case op platform companies. The selection of theories based on interviews with stakeholders could have introduced a bias, since stakeholders have their own agenda.

In chapter 4 the resource based view was used to analyse the resources of the different types of companies to understand their individual investment behaviour in submarine cables. The theory was relevant to explain the investments of telecom companies. It shows that the investment strategy of telecom carriers is directly related to their current network assets, experience in the industry and financial options. However the resource-based could not explain all of the investment drivers of platform companies such as Facebook and Microsoft. RBV was useful to describe the assets of these companies, but could not explain their investment behaviour due to the different structure and creation of value. Looking back the multi-sided platform market theory is a theory that indeed can be relevant to explain the investment behaviour of platform companies. The resource-based view could not explain this sufficiently. In future research the multi-sided platform economics theory can be interesting to explain the investment in submarine communication cable from a platform perspective.

In chapter 5 the transaction cost theory was applied to understand the governance structure between content and application providers and telecom carriers. Transaction cost theory is a theory that could explain the trend of vertical integration of platform companies. This made the transaction cost theory complementary to the resource based view. The latter was not able to explain the investment behaviour of these companies. Together the resource-based view and transaction cost economics could explain both the investment strategies of telecom operators and the investment behaviour of content and application providers. TCE was very insightful to understand the trend of vertical integration of CAPs and their investment behaviour.

Chapter 6 applied the transaction cost regulation theory to understand the effect of regulations in the Netherlands. The transaction cost regulation theory has the same perspective as the transaction cost theory but it is applied to the transaction between governments and investors. The analysis of the transaction cost regulation showed that governments can have a negative effect on the investments to a country. Analysing the effect of government regulations on the investments also helps to understand the policy options for governments.

In chapter 7, the synthesis, the factors which explain the investment behaviour of firms for investment behaviour where listed. Any double factors were taken out of the list. The next step was to compare the Netherlands and Spain based on the factors that were identified. Based on industry documents, legal documents and the interviews the two countries were compared for every factor. The construction of the factors and the comparison of the two countries on the formulated factors could have introduced bias of the researcher. The next step was the validation of the factor of the explanatory model. To what extend can this model explain the investments in submarine communication cables to a country? Also, what is the relative importance of the different factors? It was difficult to give answers to these questions since. However a quick scan of the outcomes of the qualitative comparative study shows that factors can explain reasonably well the differences in investments to both countries. Future studies should further validate by applying the model to more countries. This study was a first exploratory step to understand how the investments in submarine communication cables are made.

Chapter 8: Conclusion and discussion

The chapter contains the final conclusions of the thesis and the discussions. In the discussions found knowledge gaps are discussed which could be used for future research.

8.1 Conclusion of the study

In the thesis a framework was created to compare the investments in submarine communication cables to a country. First the interviews were conducted with experts in the submarine industry, such as investors in cables to the Netherlands and Spain, public servants and interest groups. Based on information from the interviews and industry documents theories were selected to construct a research framework. These theories are the resource-based view, transaction cost theory and the transaction cost regulation. Analysis of the submarine communication industry with these theories created insight in the factors that explain the investments in submarine communication cables to a country. Based on these analyses an explanatory model was constructed to explain firm investment decisions to a country. This first step for such a model was validated by a comparative study. In this comparative study the investments to the Netherlands and Spain were compared.

The main research question of this thesis is: '*What factors explain the investments decisions in submarine communication cables?*

The main research question was divided in three sub question:

1. How does the interconnectivity market work and which actors are active on this market?

In the interconnectivity market companies sell and buy data transit services. The two types of market players that invest in submarine cables are internet service providers, such as British Telecom and Verizon and content and application providers such as Facebook and Microsoft. Sometimes also public enterprises invest in a cable. Most of the data transit flows through submarine communication cables. The technology of the submarine telecom systems is changing rapidly. Due to new types of modulation, improved signal repeaters and 'purer' fibres the capacity increased rapidly. However to even further increase capacity different types of multi-cored fibres and new types of modulation will be required in the future. In recent years most telecom operators chose to upgrade the dry plant of the cables system. However there is a technical and economic limit for these upgrades.

2. Which factors influence investments in submarine communication cables?

Table 19 lists all the factors that influence the investments in submarine communication cables to a country. The table provides an overview of the factors that can be directly influenced by a government and factors that cannot (only indirectly) be influence by a government. There are regulatory, geographical, demographical and existing network asset factors that influence the investments. Content and application providers and telecom operators have different relative importance for the different factors. CAPs prefer to diversify their supply chain by investing in submarine communication cables between their datacentres. Therefore they sometimes chose different routes for their cables. These cables can add resilience to their supply chain. Telecom operators have usually a different strategy. These companies try to connect the regions with a large demand for transit data. These connections then are used to allow the sales of data transit services over the cable.

In general one can say that there are a lot factors that influence that influence the firm investment behaviour to a country that cannot (or barely) be influenced by a country. Such factors are 'the geographical location', 'number of cable landings' which are suitable, 'price level of data transit' and so on. These factors can have a large effect on the actual investments. For example the 'geographical location' of a country determines for a substantial part the investments. Besides the factors that cannot be influenced, there are also a handful of factors that can be influenced by the government. These are discussed in the answer of sub question three:

3. Which of the factors can be influenced by the Ministry of Economic Affairs and Climate Policy to facilitate investments in submarine communication cables to the Netherlands?

In chapter 9 a policy recommendation is provided to the Ministry of Economic Affairs and Climate policy of the Netherlands. This chapter provides recommendations to governments based explanatory model of table 19. Policy recommendations are formulated based on the factors that can be influenced by the government.

8.2 Discussion

There are a number of knowledge gaps that were identified during this research. First of all, in the interviews Mr. Rea of British Telecom argued that government regulations, such as the decrease of a maintenance zone could have an impact on the investments to a country. With help of the transaction cost regulation theory the interactions between investors in submarine communication cables and governments were analysed. Based on the transaction cost regulations you can indeed say that the reduction of the maintenance zone can reduce the investments to a certain country. However it is unsure how strong the effect is. The evaluation of the comparative case study showed that other factors are likely to be more important drivers for the investment behaviour. Therefore more research is required to understand the impact of different types of government behaviour on the investment in submarine optic cables to a country.

The second knowledge gap that was identified in this research is the effect of 'platform products' on the investments in the submarine cables. The theories used in this study were not able to explain the business case of platform companies and the developments in their products. According to Mrs. Violari of Facebook and Mrs. Crowley of Microsoft, the investments in submarine cables are done to assure sufficient data capacity in the future for their products. Therefore it is interesting to know how the value creation works for these companies. An analysis of the development of the products can help to explain the strategies of platform companies. The multi-sided platform market theory can be used to increase understand and create another perspective to analyse the investment behaviour in submarine cables.

The last knowledge gap is about the available space of the Netherlands. There are very few routes available for future cables to Amsterdam showed the analysis with the transaction cost regulation theory. However more detailed research is required to understand in detail which routes are still available, taking into account geographical factors such as the type of seabed, tides and other artificial and natural barriers.

Chapter 9: Policy recommendations for the Ministry of Economic Affairs and Climate Policy of the Netherlands

Currently the price level of submarine and terrestrial interconnection is very competitive. The reason of this is the fact that there is a surplus of available transit infrastructure. Both on the North Sea and on the Atlantic the supply exceeds the demand. There is a lot of 'non-used supply'. Therefore there is no problem on the short term in terms of interconnectivity of the Netherlands. The Netherlands also has high quality 'terrestrial backhaul terrestrial' which creates a large number of options for parties that require connectivity.

In the future a part of the current cables that land in the Netherlands will be taken out of service, since eleven of the twelve 'cables were constructed before 2003'. However it is not likely that this will be problematic. The area around Amsterdam is an important digital and financial centre which 'pulls' interconnectivity of telecom operators. On top of that Microsoft and Google, two large content and application providers have their 'datacentres located' in the Netherlands. These companies will also keep investing infrastructure to have a reliable, high capacity infrastructure to these datacentres either through investing in own cables or through leasing existing capacity.

This study shows that large content and application companies do not necessarily invest in a cable to the Netherlands. The aim of CAPs is to have diversity in the digital infrastructure that interconnects their data bases worldwide. Important here is that the connections are reliable. For this reason it is less likely that the CAPs will invest in a cable to the Netherlands. Due to the shallow waters in combination with fishing activities and shipping there is a relative 'high risk of cable failure'. The risk for cable failure is a factor which is very important to investors in submarine cables. Therefore one of the options of the Netherlands is to try to reduce this risk for submarine cables to the Netherlands.

However, this is easier said than done. The construction of windfarms at sea westwards of Amsterdam creates a barrier for cables, since cables cannot cross this in the near future, although this may change. In the short term new cables will have to make detours which increase the risks, due to less optimal routing. Windfarms have priority over submarine cables since they are defined as 'of national interest' and have priority over submarine telecom cables. The low priority of submarine telecommunication cables could have a tempering effect on investments in new submarine communication cables by CAPs and telecom carriers.

In the policy paper 'Beleidsnota wind op zee 2016-2021' the minimum required maintenance zone around submarine telecom cables was reduced from 750m to 500 meters on both sides in cases of a scarcity of space. However, 500meter is below the international industry standards. This created a disagreement between the Ministry and British Telecom. British Telecom and other Telecom carriers argue that they cannot maintain and repair some of their cables which cross a windfarm at sea. Therefore the reduction of the maintenance zone might have a deterrent effect on willingness to invest in submarine telecom cables to the Netherlands. Such changes in regulation however will not put of all investors. Some telecom operators, such as British Telecom will be likely to stay dependent on the Netherlands, due to the geographical location. Furthermore governments can argue that a maintenance zone of 500m in some parts is unavoidable. It can be seen as an effect of the increase in activities in the coastal seas of the Netherlands. Following this line of reasoning one can say that the reduction of the maintenance zone can have a positive effect. The reduction of the maintenance zone can provide an incentive for submarine telecommunication owners to work more compact and efficiently. This might have a positive effect on the spatial efficiency in the coastal seas of the Netherlands. The government of the Netherlands has to balance these two interests. The reduction of the guaranteed maintenance zone can deter future investments in cables to the Netherlands, but it can also improve the efficiency of the use of space in the sea.

Another source of influence for the government is the permit procedure for new cables. Currently this is done on 'first comes, first served' basis. The question is whether this is desirable in the North Sea, where space is increasingly scarce. A new type of permit procedure could be considered by the government for the spatial planning of the North Sea. Like on land government can force the different stakeholders at sea to work together. In this way a more efficient spatial planning might be achieved. An option is to create cable corridors together with the owners of future windfarms at sea. Corridors can provide a protection against fishing and shipping activities and increase the accessibility. The downside however is this is that corridors will decrease the energy production of the windfarms. Possible construction of windfarms at sea is especially relevant in the North Sea. The accessibility of Amsterdam for submarine cables is decreasing due to the new windfarms.

The government also has other options besides changing the spatial management of the sea. Another strategy might be to improve the business climate for datacentres. An attractive climate for datacentres will increase the data transit demand. This increase in demand then could 'pull' investments in connectivity to this area. Subsequently the increased connectivity could improve the business climate for datacentres. In this way a positive feedback loop could possibly be created. Higher density of datacentres will not directly pull cables of content and application providers as Facebook and Microsoft. Their strategy is to diversify the network and reach their network through the European terrestrial backhaul. Telecom operators however will invest more in connections to the Netherlands when the demand for data transit increases. This study did not investigate the policies which can improve the business climate for datacentres nor did it evaluate the efficiency of such a policy.

Summarizing, based on the explanatory model of this thesis a handful of factors are identified that can be changed by the government. The total list of factors which were identified is listed in table 19. However a large number of factors such 'geographical location' and 'non-used supply' cannot be changed by the government. Factors that can be changed are the 'liberalization of the telecom market, 'lowering the risks of cable failures', 'the creation of (regulated) space for future cables', 'the protection of cables', 'guaranteeing the maintenance zone' and 'government investment'.

As said, for the Ministry of Economic affairs of the Netherlands this means that there are a couple of policy options. The government could restore the minimum maintenance zone to 750m on both sides of the cable, although it is unsure whether this has a large effect. The second option is to force users of the sea to work together for a more efficient spatial division. An example of such cooperation is the construction of a corridor in future windfarms in the North Sea to keep Amsterdam accessible. Lastly the government can create policies to improve the business climate for datacentres. These datacentres could pull future interconnectivity. For all three policy options more extensive research is required to understand the precise effects and effectivity of the measures.

Bibliography

AMS-IX. (2016, November 21). *AMS-IX breaks through 5 Terabits per second ceiling.* Retrieved June 17, 2017, from Ams-ix.net: https://ams-ix.net/newsitems/293

Analysys Mason. (2018, January 30). *The submarine cable industry: new investment opportunities and key trends.* Retrieved from Analysysmason.com: http://www.analysysmason.com/About-Us/News/Newsletter/submarine-cable-industry-Jan2018?utm_term=and%20key%20trends&utm_campaign=Analysys%20Mason%20Quarterly%20%7C%20Latest%20news%20and%20opinion&utm_content=email&utm_source=Act-On+Software&utm_medium=emai

Armstrong, M. (2006). Competition in Two-Sided Markets. *The RAND Journal of Economics*, 1756-2171.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 99-120.

Beaufils, J.-M. (2000). How Do Submarine Networks Web the World? *Optical Fiber Technology 6*, 15-32.

Body of European Regulators for Electronic Communications. (2012). *An assessment of IP interconnection in the context of Net Neutrality.* Riga: BEREC.

Bray, J. (2002). *Innovation and the Communications Revolution: Fromthe Victorian pioneers to broadband Internet* (Vol. 2). London: The Institution of Engineering and Technology.

Bryman, A. (2012). Interviewing in qualitative research. In A. Bryman, *Social research methods* (p. 470). O: Oxford University Press.

Cambini, C., & Jiang, Y. (2009). Broadband investment and regulation: A literature review. *Telecommunications Policy*, 559-574.

Carter, L., Burnett, D., Drew, S., Marle, G., Hagadorn, L., Barlett-McNeil, D., & Irvine, N. (2009). *Submarine Cables and the Oceans - Connecting the World.* ICPC/UNEP/UNEP-WCMC. The United Kingdom: The Lavenham Press.

CBS. (2016). *Measuring the Internet Economy in The Netherlands: a big data analysis.* The Hague: Statistics Netherlands.

Clark, B. (2016). Undersea cables and the future of submarine competition. *Bulletin of the atomic scientist*, 234-237.

Clark, D., Peyman, F., Bauer, S., Lehr, W., Gilmore, P., & Berger, A. (2008). The Growing Complexy of Internet Interconnection. *Communications & Strategies*(72), 51-71.

CNMC. (2013, 04 15). *Nueve regulación para los cables submarinos y las líneas terminales* . Retrieved from CNMC blog, competencia, telecos, audiovisual, energía, transportes y + : https://blog.cnmc.es/2013/04/15/nueva-regulacion-para-los-cables-submarinos-y-las-lineas-terminales/

CNMC. (2018, 02 01). *La CNMC desregula la ruta de cable submarino que une la Península con Canarias.* Retrieved from CNMC.es: https://www.cnmc.es/node/366733

Coffen-Smout, S., & Herbert, G. J. (2000). Submarine cables: a challange for ocean management. *Marine Policy, 24*(6), 441-448.

DE-CIX. (2018, 04 04). *DE-CIX Frankfurt statistics*. Retrieved from De-cix.net: https://www.de-cix.net/en/locations/germany/frankfurt/statistics

Deloitte. (2014, February). *Value of connectivity: Economic and social benefits of expanding internet acces.* Retrieved June 17, 2017, from deloitte.com: https://www2.deloitte.com/content/dam/Deloitte/ie/Documents/TechnologyMediaCommunications/2014_uk_tmt_value_of_connectivity_deloitte_ireland.pdf

Desurvire, E., Nakazawa, M., & Payne, D. N. (2013). How the EDFA came to be. *SUBOPTIC' 2013*. Paris.

Dialogic. (2016). *Beyond Fast: How the speed of residential internet access will develop between now and 2022.* Utrecht: Dialogic.

Digitalgateway.eu. (2017, July 18). *Perfect Connectivity.* Retrieved July 18, 2017, from Digitalgatway.eu: Digitalgateway.eu/connectivity.html

ECORYS. (2016). *Onderzoek strategische voordelen NL.* Rotterdam: Ministerie van Infrastructuur en Milieu.

Energieprojecten, I. B. (2015). *Zienswijzen en reactie op 'Ontwerpkavelbesluiten I en II Windenergiegebied Borssele'* . Den Haag: Rijksoverheid.

ESCA. (2016). *ESCA Guideline No.6*. ESCA.

European Subsea Cables Association . (2016). *Guideline No.6 - The Proximity of Offshore Renewable Energy Installations & Submarine Cable Infrasturcture in the UK Waters.* Executive Committee ESCA.

European Subsea Cables Association. (2017, November 6). *About Us*. Retrieved from Escaeu.org: http://www.escaeu.org/about-us/

Evans, D. S. (2003). Some Empirical Aspects of Multi-sided Platform Industries. *Review of Network Economics*, 191-209.

Extending the working life of submarine cable systems. (2017, 12 26). Retrieved from Suboptic.org: http://suboptic.org/initiatives/submarine-cable-lifespan-project/

Financieel Dagblad. (2016, May 26). *Microsoft en Facebook leggen trans-Atlantische internetkabel.* Retrieved June 17, 2017, from Fd.nl: https://fd.nl/ondernemen/1153251/microsoft-en-facebook-leggen-trans-atlantische-internetkabel

Gautheron , O., & Suyama, M. (2003). Submarine Cable Networks. *C. R. Physique 4: Optical telecommunications*, 115-126.

Gautheron, O. (2008). Submarine Networks: Evolution, not Revolution. *C. R. Physique 9: Recent advances in optical telecommunications*, 1031-1044.

Google. (2018, 04 04). *Locaties van datacenters*. Retrieved from Google.nl: https://www.google.nl/about/datacenters/inside/locations/

Grimes, A., Ren, C., & Stevens, P. (2011). The need for speed: impacts of internet connectivity on firm productivity. *J Prod Anal* , 187-201.

Groenewegen, J., & Vromen, J. (1996). *A Case for Theoretical Pluralism.* Dordrecht : Springer.

Haase, N. (2009). *European gas market liberalisation : competition versus security of supply?* Groningen / Enschede: University of Twente.

ITU. (2018, 04 04). *Tnd Map Public*. Retrieved from Itu.int: http://www.itu.int/itu-d/tnd-map-public/

Klein, P. G. (2004). The Make-or-Buy Decision: Lessons from Empirical Studies. In C. Ménard, & M. Shirley, *Handbook of New Institutional Economics*. Columbia: Kluwer.

Mahlknecht, G. (2017, 12 14). *Grag's Cable Map*. Retrieved from Cablemap.info: http://www.cablemap.info/

Microsoft. (2017, September 21). *Microsoft, Facebook and Telxius complete the highest-capacity subsea cable to cross the Atlantic*. Retrieved from News.microsoft.com: https://news.microsoft.com/features/microsoft-facebook-telxius-complete-highest-capacity-subsea-cable-cross-atlantic/

Microsoft. (2018, 04 04). *Azure-locaties*. Retrieved from Azure.microsoft.com: https://azure.microsoft.com/nl-nl/global-infrastructure/locations/

Microsoft. (2018, 05 21). *Your Vision. Your Cloud*. Retrieved from Azure.Microsoft.com: https://azure.microsoft.com/en-us/

Ministerie van Economische Zaken. (2017, 08 23). *Organisatie*. Retrieved from https://www.rijksoverheid.nl/ministeries/ministerie-van-economische-zaken: https://www.rijksoverheid.nl/ministeries/ministerie-van-economische-zaken

Ministerie van Economische Zaken en Klimaat. (2016, December 05). *De toekomst van digitale connectiveit in Nederland*. Retrieved from Rijksoverheid.nl: https://www.rijksoverheid.nl/documenten/rapporten/2016/12/05/de-toekomst-van-digitale-connectiviteit-in-nederland

Ministerie van Infrastructuur en Milieu. (2012). *Structuurvisie Infrastructuur en Ruimte: Nederland concurrerend, bereikbaar, leefbaar en veilig*. Den Haag: Rijksoverheid.

Ministerie van Infrastructuur en Milieu, Ministerie van Economische Zaken. (2015). *Beleidsnota Noordzee 2016 - 2021*. Den Haag : Rijksoverheid.

Netflix. (2016, March 17). *How Netflix works with ISPs around the globe to deliver a great viewing experience*. Retrieved from Media.netflix.com: https://media.netflix.com/en/company-blog/how-netflix-works-with-isps-around-the-globe-to-deliver-a-great-viewing-experience

NL-IX. (2016, 10 19). *Traffic & Key Statistics* . Retrieved from NL-ix.net: https://www.nl-ix.net/network/traffic/

Norton, W. B. (2010). Internet Service Providers and Peering., (pp. 1-17).

OECD. (2003). *Information and Communications Technologies: ICT and Economic Growth, evidence from OECD countries, industries and firms*. Paris: OECD Publications Service.

Ostrom, E. (2011). Background on the Institutional Analysis and Development Framework. *The Policy Studies Journal*, 7-27.

Overheid.nl. (1994, November 16). *Overheid.nl*. Retrieved from Verdrag van de Verenigd Naties Inzake het recht van de zee: https://verdragenbank.overheid.nl/nl/Verdrag/Details/000493

Palmer-Felgate, A., & Booi, P. (2016). How resilient is the global submarine cable network? *How resilient is the global submarine cable network?* (pp. 1-7). Reading, United Kingdom: SubOptic2016.

Policy Exchange. (2017). *Undersea cables,indispensable, insecure.* London: Policy Exchange.

Porter, M. E. (1979, March). How Competitive Forces Shape Strategy. *Harvard Business Review*, 137-145.

Relined. (2017, November 7). *Cobra Datakabel*. Retrieved from Relined Fiber Network: https://relined.eu/cobra-kabel

Relined. (2018, 05 20). *About Relined*. Retrieved from Relined.eu: https://relined.eu/en/about-relined

Rochet, J.-C., & Tirole, J. (2003). Platform Competition in Two-Sided Markets. *Journal of the European Economics Association*.

Sanger, D. E., & Schmitt, E. (2015, October 25). *Russian Ships Near Data Cables Are Too Close for U.S. Comfort.* Retrieved June 16, 2017, from The New York Times: https://www.nytimes.com/2015/10/26/world/europe/russian-presence-near-undersea-cables-concerns-us.html?_r=0

Sen, S., & Wang, J. (2004). Analyzing Peer-To-Peer Traffic Across Large Networks. *IIEEE/ACM Transactions on networking*, 219-233.

Simmons, J. M. (2014). *Optical Network Design and Planning.* New York: Springer International Publishing.

Spiller, P. T. (2013). Transaction cost regulation. *Journal of Economic Behaviour & Organization* , 232-242.

Staatscourant. (2016). *Kavelbesluit I windenergiegebied Borselle.* Den Haag: Koninkrijk der Nederlanden.

Suboptic. (2017, 12 26). *Extending the working life of submarine cable systems*. Retrieved from Subopti .org: http://suboptic.org/initiatives/submarine-cable-lifespan-project/

SubOptic; Submarine Telecoms Forum. (2016). 5th Anniversary Edition Submarine Teleomcs Industry Report. *Submarine Telecoms Industry Report* (pp. 8-119). Submarine Telecoms Forum.

TeleGeography. (2017, June 17). *Submarine Cable Frequently Asked Questions*. Retrieved June 17, 2017, from Telegeography.com: http://www2.telegeography.com/submarine-cable-faqs-frequently-asked-questions

TeleGeography. (2017, June 17). *Submarine Cable Map*. Retrieved June 17, 2017, from Submarinecablemap.com: http://www.submarinecablemap.com

TenneT. (2018, 05 20). *About TenneT*. Retrieved from TenneT: Taking power further: https://www.tennet.eu/company/profile/about-tennet/

The Economist. (2017, October 7). *Tech giants are building their own undersea fibre-optic networks*. Retrieved from Economist.com :

https://www.economist.com/news/business/21730057-google-facebook-and-microsoft-want-more-control-over-internets-basic-infrastructure-tech

The Washington Post. (2002, January 29). *Global Crossing Files for Bankruptcy*. Retrieved from Washingtonpost.com: https://www.washingtonpost.com/archive/business/2002/01/29/global-crossing-files-for-bankruptcy/fffcad1b-f522-479a-a9d4-659e74165b05/?utm_term=.32f40ace2e90

TNO; Dialogic. (2016). *De toekomst van digitale connectiviteit in Nederland.* Utrecht.

United Nations. (2013, October 29). *Convention declerations.* Retrieved from Division for ocean affairs and the law of the sea: http://www.un.org/depts/los/convention_agreements/convention_declarations.htm

United Nations. (2018, April 03). *Legal regime regulating the laying and protection of submarine cables and its implementation.* Retrieved from https://cil.nus.edu.sg/wp-content/uploads/2009/10/UNDOALOS-PP-on-UNCLOS.pdf

Vaan de, E. M. (2012). Public and private decision-making in multi-actor systems: a structured approach to integrate theories of the firm and policy analysis theories to support policy anaysis, applied for the upstream natural gas industry. *Technology Policy and Management Journal*, 3-21.

Volkskrant. (2012, Oktober 17). *Op bezoek bij AMS-IX, een van de grootste internetknooppunten ter wereld.* Retrieved June 17, 2017, from Volkskrant.nl: http://www.volkskrant.nl/recensies/op-bezoek-bij-ams-ix-een-van-de-grootste-internetknooppunten-ter-wereld~a3333164/

Vusirikala, V., & Kamalov, V. (2016). Scaling Submarine Networks: Datacenter Operator Perspective. *SubOptic* . Dubai: Google Inc.

Wagner, E. (1995). Submarine cables and protections provided by the law of the sea. *Marine Policy* , 127-136.

Waterwet. (2009). *Waterwet.* Den Haag: Rijksoverheid.

Williamson, O. E. (1979). Transaction-cost Economics: The Governance of Contractual Relations. *The Journal of Law & Economics*(22), 233-261.

Williamson, O. E. (1989). Transaction cost economics. In R. Schmalensee, & R. D. Willig, *Handbook of Industrial Organization* (pp. 135-182). Berkeley: Elsevier Science Publishers B.V.

Williamson, O. E. (1998). Transaction cost economics: How it works; Where it is headed. *De Economics 146*, 1-36.

Winseck, D. (2017). The Geopolitical Economy of the Global Internet Infrastructure. *Journal of Information Policy*(7), 228-267.

List of abbreviations

BEREC	- Body of European Regulators for Electronic Communications
BU	- Branching Unit
CAP	- Content and application provider
CDN	- Content Delivery Network
CPA	- Cable Proximity Agreement
EDFA	- Erbium Doped Fiber Amplifier
Gb/s	- Gigabit per second
IP	- Internet Protocol
ISP	- Internet Service Providers
IX	- Internet Exchange
IXP	- Internet Exchange Provider
NCI	- New Institutional Economics
OCDE	- Organization for Economic Co-operation and Development
OTN	- Optical Transport Network
OTT	- Over-The-Top services
P2P	- Peer-to-Peer
RBV	- Resource-Based View
ROADM	- Reconfigurable Optical Add/Drop Multiplexer
ROV	- Remoted operated vehicles
RVO	- Rijksdienst voor Ondernemend Nederland
SDM	- Spatial division multiplexing
TAT(xx)	- (xxth generation of) Transatlantic telecommunication cable system
TCE	- Transaction Cost Economics
TCR	- Transaction Cost Regulation Framework
UNCLOS	- United Nations Conventions on the Law of the Sea
WDM	- Wavelength Division Multiplexing

Appendix A – Invites for the interview

Beste **[NAAM]**,

Vorig jaar hebben we, zoals je waarschijnlijk weet, een onderzoek uit laten voeren *naar de toekomst van de digitale connectiviteit in Nederland*. Naar aanleiding van het onderzoek kwamen we erachter dat we eigenlijk relatief weinig weten over zeekabels, terwijl deze vrij relevant kunnen zijn voor de Nederlandse connectiviteitspositie.

Dit was aanleiding om Rens Kamerling (faculteit Techniek, Bestuur en Management van de TU Delft) te vragen, voor zijn afstudeerscriptie, een onderzoek te doen naar het vestigingsklimaat van onderzeese glasvezelverbindingen. Het onderzoek richt zich op de identificatie van criteria die investeerders gebruiken bij het kiezen van de locatie van aanlandingspunten voor deze kabels.

Voor het onderzoek zijn we op zoek naar contactpersonen binnen marktpartijen die direct waren/zijn betrokken bij de aanleg van onderzeese glasvezelverbindingen. Zou **[Naam bedrijf]** bereid zijn om hieraan mee te werken en zou je ons kunnen helpen met specialisten binnen **[Naam bedrijf]** die bereid zijn om te worden geïnterviewd over dit onderwerp?

Veel dank alvast voor jouw antwoord!

Met vriendelijke groeten,

[NAAM]

Dear **[NAME]**,

Last year we have carried out a research regarding *'the future of the digital connectivity in the Netherlands'.* Following this investigation we noticed that there is relatively little knowledge available within the Dutch National Government regarding the business climate for submarine communication cables. However this business climate can be relevant for the international Dutch interconnectivity position .

This is the reason why Rens Kamerling (from the faculty Technology, Policy and Management of the Delft University of Technology) started a graduation project that focusses on the business climate for submarine communication cables. The research aims at understanding the different criteria that investors use for the decision for of the location of the landing points of the cables.

Right now we are searching for contacts within companies that were/are directly involved in the construction of these cables. Therefore we want to ask you if **[Name company]** is willing to help the Dutch Ministry of Economic affairs and to find the right specialist in **[Name company]** which is open for an interview regarding this subject?

Thank you in advance!

Kind regards,

[NAME]

Estimado señor **[NOMBRE],** estimada señora **[NOMBRE]**, Durante pasado año hemos realizado una investigación sobre '*el futuro de la conectividad digital de los Países Bajos*'. Después de esta investigación hemos notado que el conocimiento sobre el clima de negocios de cables submarinos de fibra óptica en el gobierno nacional Holandés es escaso.

Esta es la razón por la cual Rens Kamerling (Estudiante de la Universidad Tecnológica de Delft) ha empezado una investigación para entender mejor el clima de negocios de cables submarinos de fibra óptica. La investigación se centra en identificar los criterios que usan los inversionistas cuando deciden los puntos de aterrizaje de los cables.

Estamos buscando unos contactos en su empresa que estén involucrados en la construcción de estos cables. Por eso nos gustaría preguntarle a usted si conoce algún especialista en **[Nombre de la empresa]** que esté dispuesto a hacer una entrevista. El idoma de la entrevista es ingles, pero también es posible hacerlo en castellano.

¡Gracias de antemano!

Saludos cordiales,

[NOMBRE]

Appendix B – Example Interview guide

Submarine cable strategy Microsoft

- **Why did Microsoft decide to invest in own trans-Atlantic submarine infrastructure?**
  - Did the current cable owners not have enough capacity available?
  - What is the chance that Microsoft will join future consortia with other telecom operators?
  - Which uncertainties in the supply chain lead to the decision to invest in own cables?
  - What are the advantages of vertical integration of the supply chain?
  - Will Microsoft also invest in cable connections between European countries?

- **Why did Microsoft invest in the MAREA cable towards Bilbao?**
  - Why was Telefónica/Telxius involved as partner in the project?
  - How was the landing site chosen for this cable?
  - How are different landing sites compared, is this merely on geographical factors or also on institutional aspects?
  - Why is the cable connected to the South of Europe instead of the North Europe?
  - Which criteria does Microsoft use in order to decide whether it is going to invest in new cable and to which country?

- **Do you expect that Microsoft will also invest in Submarine Cables that connect the USA with the Northern part of Europe?**
  - Are the current connections between the USA and North-Europe enough to meet the growing data demand (taking future system upgrades into account)
  - Which landing sights /countries are considered for landing a possible future Microsoft cables toward the North of Europe?
  - Do you think that the Netherlands is an interesting candidate to land a new cable in the North of Europe and why?

Criteria for an investments decision

- **Which factors are considered when Microsoft wants to invest in a cable connection to a certain region? (What are important barriers and conditions?)**
  - What are important geographical aspects? (For example: sea depth, position, nature reserves)
  - How important is the number of existing cables on a particular route?
  - Will you invest in cables if existing data transit prices are relatively low?
  - Does Microsoft want to land a new cable as close to their datacentres as possible, or are other factors decisive?
  - Do you think new windfarms in sea are a barrier for reaching a country such as the Netherlands?
  - Do you consider the risk of fisher related damage when choosing a landing site?
  - How can countries become more attractive for investments in new submarine communication cables?

Regulatory criteria

- **Which regulations for submarine cables are considered if Microsoft wants to invest in a cable to a certain region?**
  - What do you think about the UNCLOS agreements?
  - What is the position of Microsoft regarding compulsory 'Crossing Proximity Agreements'?
  - What is the minimal maintenance zone for a cable?
  - How should crossings with windfarms be managed?

- **Will Microsoft sell the left over capacity of their cables to other data consumers?**
  - How will this left over capacity be sold to the market? (dark fibre, colours, IP Transit)
  - To which parties can sell Microsoft planning to sell the left over capacity?
  - Do you expect to make profit on the investments in the cables itself?
  - Which percentage of data capacity of new cables will be sold to the market?

- **What technical requirements are important for new intercontinental cable systems?**
  - Are the new system easily scalable?
  - How does the latency of the MAREA cable compare with other cables between the USA and Europe?
  - What are the latency requirements?
  - What other requirements are important?

Appendix C – Interview British Telecom: Gavin Rea

<u>Existing submarine infrastructure of BT</u>

- The most important part of the network of British Telecom is their 'Pan-European network'
- British Telecom is also partly owner of trans-Atlantic cables such as the TAT14
- The two cables between the UK and the Netherlands are key links within the Pan-European network. There are links through the channel tunnel between the UK and France, but the connections to the Netherlands are important to create cable seperacy. British telecom requires multiple routes to have a resilient network
- The links to Amsterdam also recognize the economic and financial importance of Amsterdam.
- The Netherlands was attractive because it could be reached without crossing the English Channel; an English Channel crossing creates a lot of risk for cable breaks and costs. Instead the North-Sea is crossed to Amsterdam which provides an easy access to Germany.
- The Netherlands was attractive because of the sandy shores and is the easiest accessible neighbor to reach the mainland of Europe from the British perspective (economic motives)

<u>Problems of maintenance and new construction of cables between the UK and the Netherlands</u>

- The Ministry of Economic affairs and climate policy of the Netherlands reduced the maintenance zone for submarine telecommunication cables in windmill farms from 750m to 500m on both sides within the EEZ waters and territorial waters. This is smaller than the guidelines of the ESCA and the international standards
- The Netherlands can decrease the maintenance zone in territorial waters and EEZ waters, since the standards are guidelines, but not legally binding
- British telecom was not consulted by the Dutch government to discuss this change in policy
- British telecom did not have a thorough understanding of the government procedures of the Dutch government regarding the maintenance zones in windmill farms at sea. The system works different than in the UK and therefore no protest were made in the past.
- Wind farm developers did not consult British Telecom because their focus is on creating as much as windmills as possible to maximize electricity generation.
- The corridor of two times 500m does not allow enough space to maintain the cables with the standard technology, this create high costs for maintenance for existing cables.
- According to British Telecom the international guidelines should be accepted regarding the maintenance zones and windfarm crossings

Future challenges

- If the Netherlands do not apply the international guidelines regarding submarine telecommunication cables there will be an impact in the future for the digital interconnectivity.
- British Telecom is not likely to lay new cables between the UK and Amsterdam if the guidelines are not applied.
- The non-compliance of the guidelines create extra costs because of increased maintenance costs. Also less optimal routes will have to be created through seabed which is less suitable; this increases the risks of a cable break and the construction costs. Longer routes also could increase the latency of the connection.
- Currently the Dutch government is creating new plans for future wind farms in the years 2023 and beyond. British Telecom wants to have engagements session between carriers, windfarm developers, Rijkswaterstaat and the involved ministry to create continuous dialogs and agreements regarding the use of the sea
- The 'right level of interaction' needs to be created with flexibility on both sides. Then the Netherlands can stay attractive for future cable landings.
- British Telecom already had conversations about this subject with Rijkswaterstaat
- A possible solution could be to design future windfarms with corridor for cables. This can only be accomplished the different stakeholders work together.
- France and Scandinavian countries are also increasing the amount of wind farms in the sea, which are a challenge for British Telecom.

Products and strategy of British Telecom

- British Telecom is not a wholesalers of interconnectivity
- Products are specific data services such as cloud services and dynamic network services to financial institutions and companies
- Strategy of British Telecom for new infrastructure:
    a. First identify to which point more capacity is required
    b. Asses the current network assets that are already available
    c. Forecast the need for new cable capacity (take into factors e.g. costs for maintenance, tax breaks and latency)
- The latency is not only important for financial institutions. Some services (think about future virtual reality meetings) need very stable connections in terms of latency. Therefore the 'change of latency' is as important as the minimum latency requirements.
- Currently no extra capacity is required in the North of Europe. Future investments between these countries will depend on the maintenance costs of the older cables. The maintenance costs of cables in the North of Europe are quite large and therefore some cables will be amortized
- Also future capacity developments are important, such as the capacity demand but also the location of the demand. (get the capacity in the right place) This depends on future technologies.
- There are no plans for investments in new submarine telecommunications by British Telecom for the near future

Other remarks

- Microsoft's strategy is to connect their different data centers. These data centers are usually placed in cool countries. This is a different strategy then British Telecom.
- The UK traditionally has been a natural hub for trans-Atlantic telecommunication cables. But there are also transatlantic connections which do not land in the UK, but in Spain and Portugal (Columbus III and MAREA)

Appendix D - Interview ESCA/Pelagian: Tony Fisk

- Mr. Fisk is the Technical & Regulatory Sub group Chairman of ESCA and Commercial Director at Pelagian Ltd (A consultant for submarine infrastructure).

Business cases new submarine fibres (consultant perspective):

- Different types of business cases for new cables:
  1. 'New connectivity' between parts of the world that are not yet well interconnected or for 'diversification' (e.g. investment in the South Atlantic between South-Africa <--> South-America, lack of data capacity became clear before the Olympics)
  2. Improve connections in a competitive route. Financial institution such as banks and financial traders compete on winner-takes-it-all-market. Latency is vital for these institutions and therefore new cables are constructed with the lowest latency possible. (e.g. Hibernia Express, shortest connection between UK and Canada)
  3. Replace old cables (It is possible that the same route can be reused)
- Very low latency cables will be paid mostly by financial institutions that can make large profits with theses cables.
- Large CAPs such as Facebook and Google want a Point of Presence for their heavy traffic to Europe

Strategic considerations:

- Shift from 'voice-data' to IP-data and therefore for new submarine fibres there can be a different landing strategy
- Landing stations are connected to an 'IP-node' directly, instead of creating separate landing point with a connection to the backbone (reduces costs of interconnection and reduces latency, provides diversity of links)
- Repair time is one of the most important variable constraints since reliability is one of the most important aspects of a submarine fibre connection ('people do not like when the internet is broken')
- MAREA-cable was landed in Spain because of a number of reasons:
  - Spain (but also Portugal) has an easy accessible coastline (straight and little coast defences, **but** strong environmental laws and bureaucracy)
  - Portugal and Spain have the most western point from Europe, and therefore the lowest latency from Southern part of USA/and the Southern Americas for a Great Circle route
  - Spain/Portugal nowadays have a good backhaul fibre connections to the rest of Europe
  - Southern parts of USA and South America the Spanish language is spoken, which lowers the cultural barrier
  - Large companies Facebook, Microsoft want to have a 'Point-of-Presence' in Europe for their heavy data
  - A connection to Spain/Portugal has a potential for reduced risk for external human cable aggression because of deep sea (small continental shelf) in comparison with the extensive shelf seas and shallower waters of the North of Europe
- Cables in the past were designed as point to point for low latency traffic. Traditional fibre technology BUs introduce latency. Coastal festoons provided short distance unrepatered

cable links. Moderns systems using new generation smart BU switching and ROADM technology can combine both approaches but with increased cost and complexity
- Large Content and Application Providers such as Facebook and Google work together with former incumbents in European countries to obtain operating license. The former incumbent runs the cable and a part of the capacity of whole fibre pairs are used by the tech companies.
- Tech companies do not want to be regulated as Telecom operators, this might also be an argument why they do not want to obtain an international operator license (the application for such a license is not particularly hard)

Analysis of geographical and market position of the Netherlands:

- A large share of the trans-Atlantic between the America and the Netherlands flows through the UK (curve of the earth) to Amsterdam
- Amsterdam currently serves as an interconnection hub (Netherlands is the closest country from the UK) Therefore the UK has good connectivity with the Netherlands for connections with the continent, but the UK is not solely dependent on these connections. The connections to the Netherlands from UK are low latency connections typically.
- The Netherlands will always have a geographical disadvantage in comparison with the UK for investments in low latency cables for financial institutions in the trans-Atlantic market (geographical position is more eastwards, higher latency)
- Amsterdam has a large number of IP-centres and data servers, these data servers make investments to the Netherlands attractive for low latency transatlantic connection but route for new cables direct to Amsterdam might be obstructed in the future because of windfarms (see next part)
- Eemshaven is a good landing place for inter-European connections, but landing a trans-Atlantic cable here has its challenges, because the connection between Eemshaven and Amsterdam has a 'latency penalty' (Current cables at the Eemshaven form a pseudo-corridor for new cables). The Waddenzee also presents some environmental constraints

Accessibility of the Netherlands (ESCA perspective)

- New wind parks in the waters of the Netherlands have tried to present reduced room for existing submarine telecommunications cables already present when a windfarm has been placed on top of the cables. This cable working has been as little as perhaps +/-250m on both sides for existing submarine fibre cables and no allowance being made for any future cables proposed
- According to ESCA guidelines at least 750m is required on both sides of the cable in proximity to a windfarm for shallow waters:
    - +/- 500 meters is required for recovery and repair operations based on vessel size, drive cable distance, water depth, grapnel operations etc. This is a minimum distance which is dictated by factors other than water depth. The water depth is not the determining factor until perhaps a depth of around 165m is reached
    - The +/-250m additional space is required in windfarms (for crew safety, waves, wind, proximity of turbines etc.)
    - On open shallow waters only +/-500m is required
- Calculation for shallow waters can be found in Guideline 6 ESCA, based on water depth, vessel size and cable drive distances. These also cover deeper waters.

- It is possible to use a remotely operated underwater vehicle (ROV) to pick up the cable, and this can use a smaller amount of sea room. However this is only possible typically up to Sea State 5 / Beaufort 6. Grapnel technology can be used to perhaps Beaufort 9. This reduces the weather dependency for repair operations (but does not remove it completely).
- Since repair time is most important variable the grapnel method is used for planning purposes by most submarine fibre cable maintenance providers and owners, so that repair operations are subject to the minimised risk of delay due to weather constraints and therefore the 750m space on both sides is important
- Mr. Fisk explains that the current maintenance zones that are being proposed introduces risks to submarine fibre owners. It is not safe to repair the cables in the windfarms near Borselle and Hollandse Kust, for example in the narrow cable zones proposed. Also there is a risk that there will be no new submarine fibers to Amsterdam when there is no acceptable maintenance zone for the cables, as potential system planners and owners will look for easier, safer, cheaper less risky landing points.
- Another barrier of the Netherlands are the coast defences 'dykes', which for at least one existing cable has placed several metres of stones on top of the cablemanhole' since the cable was installed.. The cable manhole now cannot be entered without significant excavation and this would make any repair of maintenance activity at that point, very difficult, more expensive and take more time. If the cable breaks in this point this will be a problem.
- Bureaucracy is 'strict' in the Netherlands, with a clear process and paperwork takes 6 to 9 months (however this is not especially a negative decisive factor), (non-developed countries this can be as little 4 weeks)
- For example to connect to the Eemshaven the Waddenzee has to be crossed, which requires surveys, research for mating of seabirds and habitat study. It causes or can cause a lot of conditions on the cable licence. However this overall environmental standard for habitat regulations and marine protected areasis being harmonised by the EU.

Cable corridor in windfarms

- Cable engineers do not prefer a cable corridor, but given the complexity of marine special planning it will be accepted / has to be accepted in some cases. (the push for offshore energy is becoming a key challenge)
- A possibility to keep Amsterdam accessible for new cables is to create a corridor of 1.5km (750m) on both sides of existing cables in future windfarms, then Amsterdam can be connected with the existing landing points and the routes being re-used in the future.
- It is also technically possible to put two cables in the same corridor with 300m spacing required between them, and then 750m on both sides, which is 1.8km (equal to approximately 1 nautical mile) in total
- It is even potentially possible to place 3 cables in a corridor of around 2.2 km as this gives enough space to recover the cable using grapnels, and the sea rea above the other cables gives the required operational sea room.
- Focus should shift towards 'co-exist', it is often not possible to 'co-locate' but we can co-exist and working together with stakeholders and early engagement in the process can usually result in a mutual acceptable outcome
- The specifications of a corridor should be discussed during the planning phase for renewables
    - Stakeholders are: 'Leaseholder' (Rijkswaterstaat), Ministery of Economic Affairs, Cable community and Developers of Renewables among others

- Corridors only are truly effective if the zone is properly patrolled, and if there are penalties for breaking the rule. (Corridors are vulnerable for anchors)

Influence of the development in technology on cable routes

- More pure fibres and new transmission technology extend the cable length that can be installed before the cable system requires repeaters.. In the past the maximum length of an unrepeated cable was 200km, and anything over that distance required a repeater. Currently, unrepeated cables can be used up to just under 400km. This makes it possible to connect more European landings from the UK without repeaters
- Unrepeated cables can have up to 96 fibre pairs (very high capacity)
- Transatlantic cables can typically only have 8 fibre pairs (lower capacity because the signal need to be amplified (energy supply and technology constraint)) and perhaps up to 16 but not much more than this currently
- New technology is BU ROADMS, submarine optical switches, which allows ‘branching’ the cable underwater and allows ‘dynamic traffic control’ to spread the data traffic more efficient over the network
- In the last years there are perhaps 6 plans made for a new cable between the USA and North-Europe. According to Mr. Fisk, probably 2 plans are the most realistic. These plans connect repeated cable between the USA and Western Europe with 8 fibre pairs. These proposals connect the USA with several Northern European countries with BU ROADMS technology likely to be used and higher capacity than existing systems with minimised latency. These plans are commercial viable.

Appendix E (1) Origineel - Interview Fibre Carrier Association/NL|DC: Rick van Fucht

- Dhr. Van Fucht heeft bij Relined en NL-IX gewerkt, is oprichter van de FCA en tegenwoordig is hij werkzaam voor dNL|DC (een afsplitsing van KPN die datacenter services in Nederland aanbiedt)

<u>Informatie over Relined en de COBRA-kabel</u>

- Tennet heeft Relined opgericht om de overcapaciteit van Nederlandse glasvezelnetwerken naar de markt te brengen.
- Door de jaren heen heeft Relined een meer' internationaal karakter' gekregen met verbindingen naar het buitenland, zoals naar Denemarken (via Cobra), maar ook naar Duitsland.
- Tot voor kort was een ' hybride kabel' (koppeling elektra en glasvezelkabel) zoals de COBRA-kabel voor Relined ondenkbaar, echter dit brengt grote kostenvoordelen met zich mee.
- De energie kabel voor het traject van de COBRA kabel kost ongeveer 600 miljoen euro en de glasvezel kost zo'n 15 miljoen euro. De glasvezelkabel zou veel duurder zijn geweest indien deze niet 'mee kon liften' op de elektriciteitskabel.
- Cobrakabel wordt o.a. interessant gezien voor datagebruikers voor redundante route (Relined communiceert duidelijk over risico's.) Mocht alleen de glasvezel breken dan zal de kabel niet zo snel worden herstelt. Indien de elektriciteitskabel en de glasvezel gebroken zijn, neemt TenneT automatisch het initiatief om te repareren.
- Partijen zoals Google, Apple en Microsoft en andere grootgebruikers van data zullen logischerwijs geïnteresseerd zijn om transit data in te kopen door de COBRA-kabel
- COBRA-kabel is vrij uniek omdat deze dieper ligt ingegraven, dit is namelijk nodig voor onderzeese elektriciteitskabels, hierdoor is er minder risico op breuk door bijvoorbeeld scheepsvaart.
- COBRA kabel heeft connecties tussen Nederland en Denemarken een lagere 'latency' dan landkabels, omdat het een nieuwe kabel is en de afstand al snel korter is.

<u>Additionele informatie</u>

- FCA is een belangenorganisatie die in het leven is geroepen voor de Nederlandse glasvezelleveranciers . De strategie van de FCA was eerst het zich richten op de kleinere netwerken, maar ook EuroFiber, Colt, (alle grote steden zijn aangesloten via FCA), grote partijen sluiten zich ook langzaam maar zeker aan.
- FCA behartigd de belangen van deze partijen en deelt kennis en probeert standaardisatie te bevorderen in de Nederlandse glasvezelmarkt, zodat we 'voor blijven lopen'.
- Dhr. Van Fucht kijkt het liefst aan tegen de internet economie als ' een groot ecosysteem'. Als bijvoorbeeld zeekabels zouden wegvallen, dan wordt Nederland als gebied minder aantrekkelijk voor ander soort service aanbieders in de toekomst. Hierdoor zullen weer andere services ook minder snel naar Nederland toekomen (cluster-economie).
- Voorbeeld hiervan is de toegenomen bedrijvigheid rondom de Eemshaven sinds de komst van twee internationale datakabels hier.

- Nederland heeft een zeer goed investeringsklimaat voor internetservices en glasvezelinfrastructuur. Mede door succesvolle lobby van de NFIA, de 'Netherlands Foreign Investment Agency' die onderdeel is van EZK. Andere factoren die bijdragen aan het investeringsklimaat is dat men goed Engels spreekt en de hoogwaardige internet infrastructuur.
- Apple heeft gekozen om zich te vestigen in Denemarken
- Voor kleinere partijen is een directe Trans-Atlantische kabel van groot belang omdat deze de connecties tussen bijvoorbeeld de MAREA kabel (welke land in Bilbao) en Nederland niet kunnen betalen. Het is dus van belang voor het vestigingsklimaat voor deze partijen dat er voldoende trans-Atlantische kabel verbindingen blijven bestaan. (verbinding tussen Spanje en Nederland kan bijvoorbeeld makkelijk 10.000euro/maand kosten
- Het landglasvezelnetwerk in Nederland heeft zeer lage lease prijzen door hoeveelheid aanbieders, beperkte afstanden. Duitsland is bijvoorbeeld vaak drie keer zo duur en ook België is duurder
- Als aannemers in Nederland willen graven hebben ze een 'klikmelding' nodig. Ze moeten aangeven waar men gaat graven en dan wordt er gekeken welke kabels er liggen en hoe hier mee omgegaan moet worden. Als de infrastructuurkritiek is kan het zijn dat er niet kan worden gegraven. (stakeholders werken dus samen op land, maar minder op zee)
- Vergunning aanvraagtijd voor een glasvezelkabel is rond de 8 – 12 weken, dit is normaal en heeft weinig effect op vestigingsklimaat.

Appendix E (2) Translation - Interview Fibre Carrier Association/NL|DC: Rick van Fucht

- Mr. van Fucht worked with Relined and NL-IX and is founder of the Fibre Carrier Association. Nowadays mr. van Fucht works with the dNL|DC (a separate division of KPN, that manages the datacentre services in the Netherlands)

Information regarding Relined and the COBRA-cable

- Tennet founded Relined to bring the rest capacity of their fibre network in the Netherlands to the market.
- Throughout the years Relined became more 'international oriented' with connection outside the Netherlands, such as a connection to Denmark (Cobra-cable), but also connections to Germany.
- Until recently a 'hybrid cable' (electricity cables that are combined with fibre cables) was not feasible. However the COBRA-cable is such as cable and it has high cost efficiency.
- The construction costs of the energy cables in the COBRA-cable are around 600 million euro. The costs of the fibre cables are 15 million euro. The submarine fibre connection would have been much more expensive if it was not able to 'lift on' the electricity cable.
- The COBRA-cable is an interesting option for data users that require redundant routes. (Relined is clear about the risks involved with the COBRA-cable) In case of a cable cut of only the fibre part of the COBRA cable, the cable will not be repaired (rapidly). In case both the electricity and the fibre cables are broken, Tennet will commence the cable repair procedure.
- Companies like Google, Apple and Microsoft and other high volume transit data users are very likely to be interested in buying transit data in the COBRA cable.
- The COBRA-cable is a unique cable because it lies deep in the ocean bed. Depth requirements for submarine electricity cables are stricter than for submarine fibre cables. Therefore the risks of a cable cut are lower for the COBRA-cable then for the average regular cable.
- The connection between the Netherlands and Denmark through the COBRA-cable has a lower latency than the terrestrial connection. This is due to the newer technologies that are used in the cable and the shorter length of the connection itself.

Additional information

- FCA is an interest groups that was created to serve the interests of Dutch Fibre Carrier companies. The strategy of the FCA was to first focus on the small fibre network suppliers, but on large companies such as EuroFiber, Colt (all large cities have a membership of the FCA) and other large fibre companies.

- FCA serves the interests of these members by sharing knowledge and lobbying for the standardisation of the fibre market in the Netherlands. In this way the organisation aims to sustain the leading position of the Dutch fibre market.
- Mr. van Fucht sees the internet economy as 'one large ecosystem'. For example, if the submarine communication cable connections were to be taken way, this would have negative effect on the attractiveness of other internet services companies in the Netherlands. The Netherlands as a region then would become less attractive. Therefore other types of internet services would be less likely to settle in the Netherlands (cluster economics)
- An example of the 'internet ecosystem' is the increased business activity around the Eemshaven since the landing of two international submarine cables in this area.
- The Netherlands has a high quality investment climate for internet service companies and fibre infrastructure investors. This good business climate is partly because of a successful lobby of the Netherlands Foreign Investment Agency (NFIA), which is part of the Ministry of Economic Affairs and Climate Policy of the Netherlands. Other factors that positively influence the business climate are the high level of English language capabilities of the Dutch and the high quality of existing internet infrastructure.
- Apple chose to settle in Denmark.
- A landing of a trans-Atlantic cable in the Netherlands can be very important for small internet companies because they might not be able to pay for the terrestrial connections to for example the MAREA cable. Therefore it is important that there remain sufficient landings of trans-Atlantic submarine communication cables in the Netheralnds. (A terrestrial connection between the Netherlands and Spain can easily cost 10.000 euro per month.
- The terrestrial fibre network in the Netherlands has very lease prices due to the high number of data suppliers and the short distances. For example, in Germany connections are often three times as expensive. Belgium is also more expensive.
- Contractors in the Netherlands are obliged to require a notification of digging activities before digging activities. Contractors are obliged to share to exact excavation locations. In this way they can communicate with cable owners about the location of cable so that they will not be harmed during the excavation work. If cables are indicated 'critical infrastructure' it is possible that no excavation is permitted. (stakeholders collaborate to not harm the cables on land, this is much less the case for submarine cables)
- Permits that are required for submarine communication cables can be obtained within 8 to 12 week. According to Mr. van Fucht this has little effect on the investment climate.

Appendix F - Interview Facebook: Melina Violari

- Overall goal of Facebook is to 'connect the world' and to provide their services such as the webpage, video services and in the future virtual reality.

Drivers for investments in submarine communication cables

- Grow the data capacity in order to enable online video/VR services
- Have 'diverse paths' for data traffic between the continents (primary goal), therefore another connection with Spain is very unlikely. The second cable to Europe will likely to connect the USA with the North of Europe (Facebook might consider the Netherlands)
- Submarine infrastructure is 'dated', more possibilities with state-of-the-art submarine fibres, the technology is evolving
- New own infrastructure provides better user service to the Facebook-user

MAREA-cable

- Connection between Virginia and Bilbao, which connects the South of Europe with the largest databases from the USA, which is diverse from the existing routes between the USA and Europe
- Bilbao is connected to the 'fibre network corridor' of Europe, that connects Bilbao through a backhaul connection with other large European cities such as Paris, Amsterdam, Frankfurt.
- Spain has a deep water (but quite a lot of fishers), so quite easy accessible
- Latency was not a decisive factor for the decision to connect MAREA with Spain, path diversity is a stronger argument

Decisiveness of factors that decide a new cable investment

- According to Ms. Violari it is not possible to give an exact order of 'decisiveness' regarding factors that are considered for new submarine cable investments.
- However it is possible to identify three factors that are very important:
    1. The new cable should add diversity to the infrastructure network of Facebook to increase the reliability of the network (primary goal)
    2. The new cable should increase availability of capacity to meet the growing capacity demand
    3. The new cable should be connected easily to (terrestrial) backhaul connections so that content delivery networks and data centres can be reached effectively
- Factors that are considered when the first three conditions are met are:
    4. The ease of obtaining landing permits (Facebook searches for a partner to work with in a consortium with the former incumbent/telecom provider (see next part Telefónica) In the USA it is difficult to obtain permits for submarine fibre connections with foreign countries (Special team for foreign cables)
    5. Is the landscape suitable to land a cable. Shallow waters, heavy fishing areas, windfarms and places with already a large number of submarine cables will tried to be avoided (these factors adds risk to cable faults, which are costly and take time 'set's us back')

The consortium with Telxius/Telefónica (and Microsoft) for MAREA

- Facebook already had a ‘exiting commercial relationship’ with Telefónica
- Telefónica came up with the idea for the MAREA-cable and Facebook co-funded
- Telefónica already has already a lot of experience in the submarine communication cable industry (Facebook obtain experience in this field)
- Telefónica owns good backhaul connections in Spain to connect the MAREA-cable
- Facebook owns a number of fibre pairs in the MAREA cable but will not ‘run it’
- Telefónica will run the cable and is responsible for the landing on both sides of the cable, Facebook will not require an international operator license
- Facebook currently has no plans to bring the remaining non-used capacity on the MAREA cable to the interconnection market ‘we need our capacity’ (however this might change in the future)

Technological requirements

- The aim is to ‘make the tech future proof’
- The infrastructure has to be scalable to meet future demand
- The use of industry standards (also for connections with the backhaul)

Appendix G (1) – Interview KPN: dhr. Dinkelman, dhr. van der Paard en dhr. Knol

Datadiensten

- KPN heeft één van de twee directe verbindingen vanuit Nederland naar Amerika
- Huidige systeem wordt goed benut, maar er is restcapaciteit (ook kan capaciteit geleased worden bij andere providers)
- Er is een mogelijkheid om de breedband van de huidige systemen verder te vergroten (bijvoorbeeld van 20 naar 80 'kleuren')
- Contracten tussen datagebruikers en KPN voor transitdata heeft minimale looptijd 1 jaar (KPN wil langer, 3^e partijen korter)
- Twee soorten verkoop van data:
    1. Alleen zeekabel stuk (van landingsstation naar landingsstation, zonder backhaul verbinding)
    2. Een gehele verbinding van A naar B (backhaul krijgen),

  Als KPN bij een deel van de verbinding geen eigen netwerk heeft kan capaciteit op dit stuk worden geleased
- Prijs van data gaat omlaag door nieuwe systemen met meer capaciteit, daardoor steeds lagere prijs
- Vraag naar internationale data groeit gestaag <-- video verkeer, en internationale zoekopdrachten etc.
- Latency (doorlooptijd) zeer belangrijk geworden voor financiële partijen (banken, investeringsfondsen), daarom wordt voornamelijk alleen het onderste deel van de TAT14 gebruik omdat deze korter is (lengte van kabel belangrijk voor latency)
- Bovenste deel van TAT14 wordt voornamelijk gebruikt als back-up
- Directe landkabels worden weinig gebruikt (zijn duur en vaak hogere latency door meerdere 'nodes' in het netwerk)

Voorbeeld creatie van Consortium KPN

- Een telecomprovider neemt initiatief (bijvoorbeeld AT&T)
- Eerste 'meeting' voor geïnteresseerde telecomoperators aan zee, ter inventarisatie
- Keuze aan telecomproviders; wil je mee doen ja/nee?
- Wil je een aanlandingspunt ja/nee? (indien ja --> meer betalen)
- Uitwerking route, techniek, randvoorwaarden
- 'Het consortiummodel' wordt steeds minder gebruikt

Beleid omtrent vissers en andere schepen

- Preventie: Kabel begraven 3m, kabelkaart beschikbaar stellen aan boten, boten monitoren en 'awareness' kweken
- Veel vis in de zone rondom de kabels, er wordt dus gevist (economische motieven)
- KPN monitort de locatie en vaarsnelheid van vissers
- Data over locatie en gedrag van vissers kan als bewijsstuk dienen

- Als een visser het anker legt in het onderhoudsgebied seint KPN de kustwacht in
- Bij breuk de vissersboot aansprakelijk stellen, maar: probleem bij internationale boten, ze verwisselen van vlag om aansprakelijkheid te ontlopen
- Mogelijke afspraken tussen kabelaars en vissers --> Standaard vergoeding wanneer een kabel per ongeluk wordt opgevist (zoals in het Verenigd Koninkrijk)
- Probleem: Vissers kunnen zich door deze afspraken 'opportunistisch gedragen' --> Kabels opvissen met oude boten/slechte spullen om een vergoeding te claimen

Procedure voor upgraden kabel binnen een consortium

- Vergadering geïnitieerd door één van de telecomproviders
- Oprichting van 'procurement group'
- Formuleren van eisen (data, aantal vezels) voor de upgrade door procurement group
- Uitschrijven van openbare aanbesteding
- Partijen die voldoen aan criteria, kunnen upgrade ter beschikking stellen en laten testen door technici van de procurement group
- Deze maken een overzicht van de prestaties, prijs etc. van verschillende aanbieders
- Beslissing van management (vaak wint het bedrijf welke het systeem heeft aangelegd door de juiste informatie en gebruik van dezelfde standaarden)
- Economische levensduur (inclusief upgrades) 25 jaar doordat upgraden steeds duurder wordt door verouderde systemen die op elkaar moeten worden aangesloten, de technische levensduur ligt hoger

Backhaul glasvezel Nederland

- Backhaul glasvezel netwerk voornamelijk van KPN in Nederland, maar ook andere spelers zoals Reginet, eurofiber.
- Volgens KPN is dit een goed functionerende markt
- Andere backhaul netwerken kunnen 'directer' zijn omdat het niet van origine telefoonnetwerken zijn

Huidige aantrekkelijkheid van Nederland volgens KPN

- Huidige situatie goed, hub voor Europese vasteland, maar:
- Geografie slecht, we liggen verscholen achter de UK
- Voor ons één van de drukste zeeën ter wereld
- Veel visserij en scheepvaart, daardoor relatief veel breuken van kabels --> slecht want betrouwbaarheid zeer belangrijk voor zeekabels (bedrijven houden hier rekening mee)
- Nieuwe Windmolen parken vormen een gevaar voor aanleg van nieuw kabels
- Dominante positie van Nederland staat op het spel:
    - Weinig ruimte voor nieuwe kabels
    - Veel breuken door toegenomen scheepvaart en visserij
    - Slechte geografische positie (Ierland beter voor financiële instellingen)
- Vergunningsprocedure volgens KPN niet het probleem

Mogelijk oplossingen volgens KPN

- Corridors vastgelegd voor kabels, houd rekening met 1,5 km ruimte per kabel (het liefst zo dicht mogelijk bij Amsterdam), KPN is voor 'Bundling'
- Oude kabel weghalen en op deze plek een nieuwe kabel leggen?
- Mogelijk combineren van energiekabels met onderzeekabels (Dit is lastig want reparatiecontracten van telecombedrijven zijn beter dan die van elektriciteitskabels en telecomkabels vergen hoge betrouwbaarheid)
- Vissers makkelijker aansprakelijk kunnen stellen voor breuken van kabels?
- Windmolen parken mag nu niet gevist worden, mogelijk save-haven voor de kabel (samenwerking windmolenparken en telecomproviders)

Spanje Telefonica Marea-kabel

- Facebook en Microsoft willen meer controle over de data verbindingen tussen datacenters
- Daardoor leggen deze partijen nieuwe kabels aan 'verticale integratie' tussen datacenters
- Om een kabel naar Spanje aan te leggen is er een 'landingsrecht nodig'
- Deze landingsrechten zijn allen uitgegeven aan telecomproviders (incumbent) en daarom hebben Microsoft en Facebook Telxius betrokken bij de MAREA-kabel
- Nederland heeft geen landingsrechten en daarom is het onwaarschijnlijk dat een bedrijf als google/facebook gebruik zou maken van KPN (Samenwerking zou eerder gezocht worden voor de backhaul-verbindingen op land)

Appendix G (2) Translation – Interview KPN: Mr. Dinkelman, Mr. van der Paard en Mr. Knol

Data services

- KPN partly owns one of the two direct connections between the Netherlands and the USA
- Current submarine connections are utilized sufficiently, but there is rest capacity (In case of a lack of capacity, transit capacity can be leased from other carriers)
- Another possibility is to expand the number of 'colours' that are send through the cable (For example: raise the number of wavelengths from twenty to eighty)
- Contracts of data transit between tenants and KPN have a minimal duration of one year. (KPN prefers longer, most tenants shorter)
- KPN sells data in different ways:
    1. Only data capacity on the submarine cable (landing point to landing point), without backhaul connections
    2. A complete connection between A and B (also deliver backhaul connections towards and away from the submarine cable

  If KPN lacks the required connections it can lease connections to connect A to B.
- The price of data transit is decreasing due to new technologies to increase capacity over existing cables
- Demand for international transit data is continuously growing (Reasons that were mentioned: video traffic, international search tasks and so on)
- Latency is increasingly important for financial actors (banks, investment firms). For this reason only the lower part of the TAT14 is used. (This part of the cable is shorter and therefore has a lower latency)
- The top part of the TAT14 ring is the backup
- Direct terrestrial backhaul cables are not used often. They are expensive and have a higher latency because of a higher number of switching points/nodes.

Procedure of the creation of a consortium

- A telecom provider takes the initiative (for example AT&T)
- A first meeting is organized for interested telecom carriers, to assess the interst
- Telecom providers have to decide, participate yes/no?
- Do you want to have landing points? Usually a higher investment is required to get a landing.
- Next step is to design the route, choose technology and formulate conditions for the construction and operationalisation of the cable
- The consortium model is used less and less

Policy of KPN regarding fisher boats and other vessels

- Prevention damage to the cable: Submarine cable are buried three meters in the seabed, information about the location of the cables is shared with the users of the sea, boats are monitored and awareness is created
- Usually there is a lot of fish around the submarine communication cables, fishermen like to fish around these places (economic motives)
- KPN constantly monitors the location and sailing speed of vessels close to the cables

- Data about the location and behaviour of fisher boats can be used as evidence in case of a cable cut
- KPN contact the coast guard if a fisher boat throws out the anchor within the maintenance zone of a cable
- Fishers can be held liable for cable cuts. However for international vessels this is harder. The boats can change flags/nationality to avoid an insurance claim
- A possible solution is to create an agreement between the telecom carriers and the fishers. A carrier could compensate fishers that pick up a cable by accident. (These agreements exist in the UK)
- However it is likely that fishers will abuse these agreements by picking up cables with old gear on purpose to claim a compensation

Procedure to upgrade a submarine cable of a consortium

- A meeting is set by one of the investors
- A procurement group is established
- Requirements (number of fibers/capacity) for the upgrade are determined by the procurement group
- Procurement procedure is started
- Companies that meet the requirements can make the proposed upgrade available to technicians the procurement group for testing
- The technicians make an overview of the performances, price of the different propositions
- The management of the companies decide which upgrade will be chosen (most of the times the company wins the procurement that constructed the system in the first place. They have the most information about the system and use the same standards)
- Economic lifetime (including upgrades) of a cable is around 25 years. Upgrades for the system are increasing in price because of the outdated hardware of the system. These systems need to be interconnected, which is costly. The technical lifetime of a submarine cable is longer

Optic backhaul in the Netherlands

- Most of the backhaul connections in the Netherlands are owned by KPN. However there are other players such as Reginet and Eurofiber
- According to KPN the market is functioning well
- Other backhaul networks in the Netherlands might be ‘more direct’, because the network of KPN was originally a telephone network

Current attractiveness of the Netherlands for submarine cable landings

- Currently the Netherlands has a hub function to the main land of Europe, however:
- The Netherlands is tucked away behind the UK (not the ideal geographical location)
- The sea in front of the Netherlands is one of the busiest seas in the world
- There is a lot of fishing activity, shipping and therefore quite a number of cable cuts. This is bad for future investments because it reduces the reliability of submarine communication cables that land in the Netherlands. The reliability is a very important factor for companies that invest in a new cable)
- New windfarms at sea reduce the probability of investment in new cables to the Netherlands in the future

  - Very little space available for new cables
  - Relative high number of cable cuts because of the increased fishing activity and shipping
  - Bad geographical position (Ireland has a better location to attract financial institutions)
- Obtaining permits for cables is not the bottleneck

Possible solutions for these problems

- Create corridors for submarine communication cables. Take into account the 1.5km maintenance zone for every cable. KPN prefers to have corridor as close to Amsterdam as possible)
- KPN is in favour of cable bundling
- It might be possible to replace old cables with new cables?
- It might be helpful to combine electricity cables with submarine communication cables. However in practice this is difficult. Repair contracts for electricity cables have worse terms then the repair contracts of telecom operators. Telecom cables require higher reliability.
- It should be easier the hold the fisher liable for cable cuts
- Windmills might be a safe-haven for future cables, it is not permitted to fish in these waters (windfarms therefore should work together with telecom operators)

Spain, Telefónica Marea cable

- Facebook and Microsoft want more control over their data flows between their data centres
- This is the reason that these parties invest in new submarine communication cables between their data centres. (Vertical integration)
- In order to be able to land a cable in Spain you need a 'cable-landing-permit'
- Only telecom operators can obtain such a right to land, this is why Microsoft and Facebook involved Telxius in the MAREA project
- In the Netherlands it is not required to obtain a right-to-land. KPN says it is unlikely that companies as Google/Facebook would involve KPN in a submarine cable project for this reason. (Cooperation between Google/Facebook and KPN would most likely focus on using the backhaul connections of KPN)

Appendix H – Interview Microsoft: 21 November: David Crowley

- Mr. Crowley is part of the team that interconnects datacentres. These datacentres are used for Microsoft products such as cloud applications

Goals of the interconnection team

- Create long term connectivity
- Create diversity in the supply chain for a reliable network
- Manage the Microsoft supply chain, have enough data capacity for future products

Developments interconnectivity strategy of Microsoft (in chronologic order)

1. Microsoft started to sell consumer services and bought data traffic capacity on a small scale
2. Microsoft bought wholesale servicers from telecom carriers, which cut costs by 63%
3. Co-built and co-buy strategy. Microsoft invested in the Hybernia express of Aquacom (now called GTT express) and could use some fibre pairs.
4. Microsoft started to build own cables as part of a consortium and owns beside software now also physical infrastructure. Microsoft became the landing party for the MAREA cable in USA and constructed own terrestrial network in the USA. (From this phase on Microsoft has enough capacity between the USA and Europe for the foreseeable future. Microsoft has three different trans-Atlantic routes which gives them high capacity and diversity.
5. Monetization of the optic fibre network. Strategy is to exchange capacity on their own cables for capacity on cables everywhere else. (Microsoft will not sell capacity, 'we do not have the expertise of a telecom carrier')

Why did Microsoft start to build own infrastructure

1. Microsoft took an order for a product from a costumer
2. Microsoft had to no own infrastructure and therefore they had to ask data traffic suppliers for capacity
3. Suppliers of data traffic capacity did not have the required capacity
4. It took too long and customer went to Amazon --> 'costumer is never coming back'
5. Microsft decided to invest in own infrastructure to ensure data traffic capacity for new customers and new products in the future. The mentality now is: 'Always be ready' (think about; Internet of things services, VR, 4K streaming) There can be no 'supply chain risk' and this is why those long term investments where made.

Other reasons for own infrastructure

- Microsoft was unhappy about the existing data suppliers because the cables had '15 – 20 year old tech'. These cable will never be able to stream for example 8K.
- Not enough diversity, hurricanes can causes cable errors close to the USA, this is why Microsoft has now strict diversity requirements for submarine optic fibre cables to create network resilience (Landing stations of trans-Atlantic cables are widely separated in: Halifax, New York and Virginia Beach)

Shift in Paradigm needed according to Mr. Crowley

- Tech companies now on the software products such as cloud services. However they work together for investments in submarine optic network infrastructure
- Life expectancy of current cables are 20 to 25 years. However to meet future capacity different fibres will be needed and therefore industry should work together to be able to construct cables every 10 years. (for example for multicore fibres, honeycomb structure instead of fibres with silicon)
- High capacity more low cost systems needed in the future

Partnership Microsoft with Telefónica for MAREA

- This was a 'recommendation' from high in the organization structure of Microsoft
- Telefonica has a lot of experience to maintain and operate the cable, 'we do not have to operational guys'
- If tech companies such as Facebook and Microsoft want to invest in a new cable they 'bring in telecom carriers'. They pitch why they are the best and then they decide

Trends in Europe

- According to Mr. Crowley 'Denemark is 'becoming hot', but also Ireland and Amsterdam are important hubs
- Triangle connection between Denemark, the Netherlands and Ireland might strong network resilience
- Different routes through Europe are possible, through Rome and Paris
- Sicilia and Marseille are nodes with a lot of connections to the Middle-East such as Egypt
- Connections to and in Europe relatively easy, much more 'challenges' in China, Russia and Middle-East such as Egypt because of culture differences

Importance of latency

- Within a region (such as Amsterdam) the latency between datacentres are very important because the different servers work 'as one'
- Between regions it is 'nice to have a low latency' because you want to have fast uploads for costumers services (e.g. Police forces require fast connections)
- Some companies need to replicate all the service around the world constantly, for this you need a lot of capacity. Microsoft does not need to do this yet but might be in the future. You want to have the capacity for future products

History of trans-Atlantic capacity of Microsoft

- 2013: 10 Tbits
- 2014: 13,5 Tbits
- 2015: 18 Tbits
- 2016: 18 Tbits
- 2017: 20 Tbits

Route decisions

- Microft takes into account seabed, shipping lanes, history and uptime of cables in the same route, existing backhaul connections, environmental regulations, geographic information and the existence of datacentres

Appendix I(1) Origineel – Ministerie van Economische Zaken en Klimaat, directie Energie en Innovatie: Marjanne Botman

- Marjanne Botman is werkzaam bij het ministerie van Economische Zaken en Klimaat in de Cluster Energie en Innovatie

Casus British Telecom VS windparken

- Afstand tussen windmolen en kabels moeten aan beide zijden tenminste 580m zijn (500m zonder wieken)
- British telecom wil voor onderhoud tenminste 750m hebben aan weerzijden voor hun glasvezelkabel. Dit komt neer op een totale vrije zone van 1,5km om de kabel heen.
- Daarnaast wil British Telecom spreiding van kabels om risico meerdere kabelbreuken op het zelfde moment te verminderen.
- Binnen de huidige ESCA6 richtlijnen (onderlinge afspraken van kabelaars voor afstand tussen kabels voor onderhoud) is een vrije zone van 500m aan weerskanten 1 km in totaal afgesproken
- British Telecom wil 1,5km zodat ze met een oudere (en dus goedkopere) boot het onderhoud en repareerwerkzaamheden kunnen blijven verrichten.
- In Duitsland en Denemarken is voor de bouw een CPA (Cable Proximity Agreement) verplicht voor de aanleg van een windmolenpark.
- British Telecom heeft dit geweigerd en heeft zo een vergoeding van de Duitse overheid en bedrijven afgedwongen voor de extra kosten door nieuwe windmolenparken. Bedrijven waren verplichtingen aangegaan voor de bouw van windmolenparken en konden daardoor niet de bouw uitstellen.
- In Nederland is er geen verplicht CPA voor windmolenparken
- Voor nieuwe windmolenparken op zee is er een conflict tussen British Telecom en de eigenaren van de windmolen parken. British Telecom wil de extra kosten vergoed krijgen van de Nederlandse overheid voor de extra kosten die worden gemaakt van de onderhoudszone door nieuwe windmolenparken.
- Volgens Marjanne Botman is British Telecom afhankelijk van Nederland voor de landing van onderzeese glasvezelkabels naar het vaste land. 'Daarom overspelen ze hun hand'.

Betrokken overheidsinstanties voor de aanleg en beleid van onderzeese glasvezelkabels

- Ministerie van Infrastructuur en Waterstaat: Verantwoordelijk voor het beleid op zee
- Rijkswaterstaat: Uitvoerend Organisatie van het Ministerie van Infrastructuur en Waterstaat
    - Voor de aanvraag van een vergunning voor de aanleg van een nieuwe kabel is een werkplan en een milieu effecten rapportage nodig. Rijkswaterstaat kan een vergunning afgeven voor een nieuwe kabel in de Nederlandse territoriale wateren
- Kustwacht: Is het controlerend orgaan van het Ministerie van Infrastructuur en Waterstaat. De kustwacht controleert de veiligheidseisen voor zeekabels.
- Ministeries van Economische zaken en Milieu is verantwoordelijk voor het beleid voor windparken (dus ook op zee).

- Rijksdienst voor Ondernemend Nederland (RVO): Is het uitvoerend orgaan het Ministerie van Economische Zaken en Klimaat. RVO zorgt voor de uitvoering van nieuwe windparken.
- Waterschap is de beheerder van duingebied waar nieuwe kabels doorheen lopen om te landen.
- Provincie geeft vergunning af voor het landdeel van de zeekabel over het land van de provincie.
- Gemeente geeft vergunning af voor het landdeel van de zeekabel over het land van de gemeente.

Barrières voor aanleg nieuwe zeekabels

- Bestaande olie en gasleidingen
- Bestaande boorplatformen (Inclusief omliggend veiligheidsgebied voor helikopters)
- Natuurgebieden
- Vaargeulen met intensief vaarverkeer
- Zandwingebieden
- Gebieden met bommen die stammen uit de tweede wereld oorlog
- Oefengebieden van defensie

Analyse situatie Nederland wat betreft zeekabels

- Nederlandse Noordzee wordt steeds drukker en daardoor moeilijker en duurder om kabels aan te leggen
- Nieuwe windparken vormen grote barrière voor nieuwe kabels
- Er wordt in besluit 'Routekaart wind op Zee' van het Ministerie van Economische Zaken en Klimaat geen rekening gehouden met onderzeese glasvezelkabels
- In de Waterwet zijn kabels ondergeschikt aan gas, vaar en windparken. Binnen de wet zijn ze zijn niet van 'Nationaal belang'
- Groot Brittannië is grotendeels afhankelijk van Nederland voor connecties met het Europese continent
- Noordzee is zeer ondiep. Dit is gunstig voor windmolenparken maar nadelig voor onderzeese glasvezelverbindingen.

Oplossingen om Nederland bereikbaar te houden

- Maak een corridor die vrij is voor alle toekomstige kabels, stroomlijn alle overheidsorganisaties in deze regie. Kijk hierbij naar de geografie, wat is handig?
- Leg nieuwe kabels op bestaand tracés. Echter, mevrouw Botman weet niet of hiervoor een nieuwe milieu effecten rapportage voor nodig is.

Appendix I(2) Translation – Ministry of Economic Affairs and Climate Policy, department Energy and Innovation: Marjanne Botman

- Marjanne Botman is attached to the Ministry of Economic Affairs and Climate Policy, specifically the department Energy and Innovation

Case: British Telecom and new windfarms

- The distance between windmill at sea and a submarine communication cable should be at least 580m on both sides (500m if the rotor blades are excluded)
- According to British Telecom at least 750m is necessary on both sides of a submarine communication cable for maintenance activities. Therefore they state that a free zone of at least 1.5km is required around a submarine communication cable.
- British Telecom favours spreading the submarine communication cables. In this way it can reduce the risks of multiple cable cuts at the same time
- According to the ESCA6 guidelines (the mutual agreements between submarine communication cable owners which determines the maintenance zone around cables) the free maintenance zone around a cable is 500m on both sides, therefore 1km in total
- British Telecom demands 1.5km because they have contracts with older (and therefore cheaper) types of maintenance and repair ships which require more space
- In Germany and Denmark the governments oblige wind farm builders to have a Cable Proximity Agreement (CPA) with submarine cable owners before starting the construction.
- British Telecom refused a CPA with windfarm builders in Germany and was able to force a compensation of the German government and the windfarm companies to mitigate the extra maintenance costs. Windfarm companies had commitments to build the windfarm and therefore were not able to postpone the construction work.
- In the Netherlands there is no compensatory CPA to obtain a license for windfarm at sea construction work.
- There is a conflict between British Telecom and the owners of future new windfarms at sea in the Dutch territorial waters. British Telecom demands compensation of the government of the Netherlands for the extra maintenance costs due to the new windfarms at sea.
- According to Marjanne Botman Britsh Telecom 'overplayed there hand'. British Telecom is dependent of the Netherlands for cable landings to the European continent.

Governmental institutions that are concerned with the policy regarding submarine communication fibres

- Ministry of Infrastructure and Water Management: is responsible for the management at sea
- Rijkswaterstaat: is the executing body of the Ministry of Infrastructure and Water Management
    - The application procedure of a construction permit for a new submarine communication cable requires a 'work plan' and an environmental impact assessment. Rijkswaterstaat can issue permits for cables in Dutch territorial waters.
- Coastal guards: is the monitoring and controlling body from the Ministry of Infrastructure and Water Management at sea. The coastal guard checks the safety requirements of submarine communication cables.
- Ministry of Economic affairs and Climate Policy is responsible for policy regarding windfarms (terrestrial and at sea)
- Netherlands Enterprise Agency (RVO): is the executing body of the Ministry of Economic affairs and Climate Policy. RVO manages the construction of new windfarms
- Water board manages the dune areas that submarine communication cables cross after landing at the beach
- The province issues permits for a construction of a submarine communication cables on the terrestrial part on land of the province
- The municipality issues permits for a construction of a submarine communication cables on the terrestrial part on land of the municipality

Barriers for the construction of submarine communication cables

- Existing submarine infrastructure of the oil and gas industry
- Exist drill platforms (Including the surrounding safe zones for helicopters)
- Marine nature reserves
- Shipping routes with intensive marine traffic
- Sand extraction areas
- Areas with bombs remnant from the second world war
- Practice areas of the army of the Netherlands

Analysis of the reachability of the Netherlands with submarine communication cables

- In the North Sea in front of the Netherlands there is increasingly industrial activity, which makes it harder to construct new submarine cables
- New marine windfarms could create a barrier for new submarine communication cables

- In the current policy document of the Ministry of Economic affairs and Climate Policy, 'Routekaart wind op zee', the construction of future submarine communication cables is not taken into account
- In the Dutch 'Waterwet' (water law) submarine communication cables are subordinated to oil and gas infrastructure, shipping activity and windfarms at sea. The Waterwet does not consider submarine communication cables as infrastructure of national interest.
- Great Britain is largely dependent of the Netherlands for backhaul connections with the European continent
- The North Sea is very shallow. This is an advantage for the construction of marine windfarms. For submarine communication cables however, this is a disadvantageous.

Policy options to keep the Netherlands accessible

- Create a corridor in the infrastructure at sea for future communication cables. 'Streamline' all the governmental institutions for this corridor. Take into account the geography for such a corridor.
- Construct new submarine communication cables on existing routes of old cables after removing them. Ms. Botman is unsure whether this requires a new environmental impact assessment.

Appendix J(1) Original – Interview Ministerie Economische zaken en Klimaat; Joost Vermeulen

<u>Windmolenparken op zee</u>

- Volgens Joost Vermeulen die bezig is met 'wind op zee 2020' zijn vormen windparken en andere gebieden geen barrière voor de aanleg en onderhoud van onderzeese data communicatie verbindingen.
- De gebieden voor windmolenparken opgenomen in het Nationaal waterplan
- Wet ' wind energie op zee' vormt de basis voor kavelbesluit en aanbesteding van kavels op zee
- De rest van zee ook in een park kan gebruikt worden voor andere doeleinden (zeewierkweek, zeekabels)
- Onduidelijkheid of bedrijven akkoord zijn met een onderhoudszone van 500m. Volgens Joost vinden de meeste bedrijven dit goed, maar British Telecom niet.
- Britsh Telecom en het Ministerie van Economische zaken hebben een conflict. British telecom wil minstens 750 meter voor onderhoud aan hun kabels in nieuwe windmolenparken. Ze hebben namelijk onderhoud contracten met boten met een grote draaihoeken. Daarom willen ze dat windmolenparken/overheid een vergoeding betaalt voor de extra kosten die men moet maken
- In andere landen zijn 'crossing proximity agreements' tussen private partijen verplicht en daardoor kan BT in bijvoorbeeld België geld claimen. In Nederland is dit niet verplicht en daardoor kunnen bedrijven langs elkaar heen werken.
- Een mogelijke rechtszaak tussen het Ministerie van EZK en British Telecom zal tot en met de Raad van State worden genomen jurisprudentie

Appendix J(2) Translation – Interview Ministery of Economic Affairs and Climate policy; Joost Vermeulen

<u>Windfarms at sea</u>

- According to Joost Vermeulen, which is involved with the policy paper 'windfarms at sea 2020' winfarms at sea are no barrier for the construction and maintenance of submarine communication cables
- Areas for future windfarms at sea are described in the 'National water plan'
- The law 'windfarms at sea' is the basis for the lot decision and the procurement of the lots for windfarms at sea.
- The area in which the windfarms are build can also be used for other functions, such as seaweed breeding and the telecom cables
- It is unclear whether companies approve the maintenance zone of 500m. According to mr. Vermeulen most telecom carriers accept this. However British Telecom does not.
- British Telecom and the Ministry of Economic affairs of the Netherlands have a conflict. British Telecom says it requires at least 750m for the maintenance around their cables when a windfarm is built around an existing cable. The boat they use maintenance require a large rotation angle. Therefore they want to have a compensation of windfarm at sea owners/government for the extra costs that have to be made because of the reduced maintenance zone.
- In other countries 'crossing proximity agreements' between crossing parties are compulsory. For example in Belgium British Telecom has a possibility to demand money for a crossing. In the Netherlands CPAs are not compulsory. Therefore there is a risks of miscommunication between the different users of the sea.
- A possible lawsuit between the Ministry of Economic affairs and British Telecom will be taken up to the highest court (Raad van State) for jurisprudence.

Appendix K(1) Original – Interview Relined: Rosalie Weijers

Structuur van Tennet

- Tennet en Energinet werken samen met de Cobra kabel
- TenneT heeft Relined als aparte organisatie welke de overcapaciteit op de glasvezel netwerken van Tennet, Prorail en BT beheerd.
- Relined valt niet onder de overheidsregulering van Tennet
- Tennet is voor 100% in handen van de Nederlandse overheid (Cobra kabel is dus half in handen van de Nederlandse overheid)
- Energinet (TenneT van Denemarken) heeft 'andere helft' van de Cobra kabel in handen en is wel gereguleerd door de Deense overheid
- Verkoop van Relined is georganiseerd door organisatie, die van Energinet wordt door 1 persoon gedaan.

Eigenschappen van Cobrakabel

- Corbra wordt meegelegd met een electriciteitskabel welke ten doel heeft meer integratie van elektriciteitsnetwerken (driver Duurzame Energie)
- Twee 'Hoofdelektriciteitskabels' met daar 'bovenop' een kleine optische glasvezel kabel
- Glasvezel kabel heeft 48 'fibers', waarvan er 6 fibers voor controle netwerk zijn van de energieprovider en 4 reserve
- Cobra kabel voor de helft Fysiek/geografisch van Tennet andere hele helft van Denen. Er wordt vergoed voor het gebruik van het 'Deense deel' (en andersom)
- Electriciteits-functie heeft voorang op glasvezel functie, dit heeft de volgende implicaties:
    1. Kabel is 6 tot 10 meter ingegraven door hogere normen voor elektriciteitskabels
    2. Als de gehele kabel (electriciteitskabel inc. Fiber) knappen is er een langere reparatietijd, (40 tot 80) dagen, echter de kans op een breuk is zeer klein
    3. Wanneer alleen de fiber kabel knapt wordt deze niet vervangen omdat hiervoor de elektriciteit van de kabels die erbij liggen zou moeten worden stilgelegd --> dit wordt niet gedaan omdat elektriciteit prioriteit heeft (black swan risk)
- Aanlandingspunt van Cobra kabel bij de Energiecentrale Eemshaven, hier moet Relined nog een glasvezel verbinding naartoe aanleggen
- Er is nog een knooppunt tussen Amsterdam en Eemshaven die nieuwe gevraagde capaciteit nog niet aan kan, dit wordt momenteel verholpen
- Verbinding naar Denemarken sneller dan over land (lagere latency, minder laspunten)
- Denemarken heeft een knooppunt welke weer naar Noorwegen gaat
- TenneT moest bij de aanleg van de Cobra kabel ook rekening houden met toekomstige Windparken en hiervoor capaciteit reserveren om deze aan te sturen
- Cobra kabel heeft low-latency en low-loss / dispersion

Businesscase TenneT/Cobra

- Relined heeft verschillende backhaul netwerken in Nederland in beheer welke men verkoopt als 'Dark Fiber'
- Op deze netwerken wordt de overgebleven capaciteit verkocht aan grote partijen, zoals Google, maar ook aan kleinere partijen, welke ze zelf moeten belichten
- Contracten voor verbindingen op land ten minste 1 jaar, op zee waarschijnlijk ten minste rond de 5 jaar

- Rond Amsterdam heeft Tennet ook een fijnmazig netwerk (ivm AMS-IX)
- Er wordt geen prijsdiscriminatie toegepast, prijzen zijn wel afhankelijk van aantal meter, aantal vezels, duur contract
- Probleem bij verhuur van Cobra is lagere garanties voor betrouwbaarheid, omdat de kabel is gekoppeld aan de elektriciteitskabel, hierdoor lagere prijs
- Prijs mag niet lager liggen dan de markt prijzen, dit kan marktverstorend werken en Relined is een overheidsbedrijf
- Relined zoekt huurders via inventarisatie via een consultant
- Andere mogelijke klanten worden direct benadert via Relined (Google heeft al interesse getoond)
- Banken en grote bedrijven hebben vaak graag een eigen fiber omdat ze zo zekerweten dat niemand de data aftapt
- Er staan momenteel geen nieuwe zeekabels op het programma
- Eigenschappen business cases:
    1. Eigenaar huurt kabel en legt zelf kabel naar aanlandingspunt of gebruikt hiervoor Relined Backhaul
    2. Er wordt geëvalueerd of de Cobra kabel niet beter kan worden geveild om meeste waarde uit de kabel te halen
    3. Relined verkoopt Darkfiber aan derde partij welke hem vervolgens ook weer doorverhuurd belicht aan een 4'de partij, hiermee kan mogelijk hoger tarief gevraagd worden (colored fiber, managed fiber, hier mist kennis voor bij Relined zelf)
    4. Relined gaat fiber helemaal van Amsterdam naar Denemarken aanbieden over land en via de Cobrakabel
- Transit markt volgens Rosalie Weijers niet verzadigd --> Data groei, meer partijen willen dataservices afnemen

Appendix K(2) Translation – Interview Relined: Rosalie Weijers

Structure of Tennet

- Tennet and Energinet cooperate in the Cobra cable project. (Submarine Communication Cable that connects the Eemshaven, the Netherlands with Denmark)
- Relined is a subsidiary organization of TenneT. The goal of Relined is to manage the residual/not-used capacity of fibre networks in the Netherlands of TenneT, Prorail and British Telecom.
- Relined is not regulated as a government body, but the organization is owned 100% by the government (Therefore the Cobra cable is owned for 50% by the Dutch government)
- Energinet (TenneT of Denmark) owns the other 50% of the Cobra cable. Energinet is regulated by the Danish government
- The sales of Relined is organized by the organization itself. The sales of Energinet is done by one person.

Properties of the Cobra cable

- The Cobra optic cable is constructed in combination with an electricity cable. The aim of this cable is to integrate the European electricity networks. (Driver is sustainable energy)
- The cable consists of two 'main electricity cables' with on top in between a small optic fibre cable.
- The optic cable consists of 48 fibres of which 6 fibres are reserved for the control system of the energy providers and 4 fibres as stand-by.
- The Cobra cable is split up in two geographical parts, the Dutch side is owned by Tennet and the Danish side is owned by Energinet. Both organizations pay each other fees for the traffic on the other side of the cable.
- The electricity function of the cable has priority over the data traffic function. This has a number of implications:
    1. The cable is buried deeper in the seabed than normal, because of more strict requirements for electricity cables
    2. In case of a cable cut (electricity cable including fibre) there is a relative long time for repair, (40 to 80 days), however a cable cut has a low probability.
    3. In case of a cable cut in only the optic fibre the optic fibre will not be repaired. The reparation of the optic cable then would require to take the electricity of the electricity cables. However this will not be the case since the electricity function of the Cobra cable has priority of the data traffic function. (Black Swan Risk)
- The Cobra cable lands close to the energy plant in Eemshaven. Relined will invest in a terrestrial backhaul connection to the landing point.
- There is node in the network of Relined between Amsterdam and the Eemshaven that does not have the required capacity. Relined will invest in this node to meet the capacity requirements.
- The Cobra cable provides a faster alternative for connections between the Netherlands and Denmark. The terrestrial alternatives have a higher latency due to a higher number of 'switching points' and a longer route.
- In Denmark there is a node for connections to Norway
- Tennet reserved a part of the data capacity for future windfarms in the sea. This capacity can be used to control these windfarms
- The Cobra cable is very low latency and low-loss/dispersion

Business case TenneT(Relined)/Cobra

- Relined manages the overcapacity of different backhaul networks in the Netherlands. Relined sells this capacity as dark fibre.
- The capacity is sold to large companies like Google but also to smaller enterprises. Users of the cables need take care of hardware to 'light' the dark fibre.
- Contracts for terrestrial connections are at least one year. Submarine cables will require a minimum contract term of five years
- Relined also manages a fine-meshed network around Amsterdam (partly for the AMS-IX)
- Price discrimination is not applied, prices are based on factors such as the length of the leased fibre, number of fibres and length of the contract.
- The lease of the Cobra cable is tricky because of the lower reliability guarantees due electricity cable. This will lower the price.
- The lease prices cannot be lower than the market prices since this can disrupt the market. Relined is owned by the government
- Relined is assessing possible tenants through a consultant
- Other possible tenants are directly contact by Relined (For example: Google showed interest in the Cobra cable)
- Banks and large companies prefer to lease fibre to make sure nobody tapes the data traffic
- Relined will not invest in another submarine cable in the near future
- Possible business cases for the Cobra cable:
    1. Tenant leases a part of the cable and invests in a private cable to the landing point of the Cobra cable or uses the backhaul network of Relined
    2. Relined is also evaluating to option to auction the data capacity on the cable to maximize value
    3. Relined sells the dark fibre to a third party, which then can rent the cable to other companies. (The third party for example deliver higher quality of services such as coloured fibre, managed fibre. Relined does not have to knowledge to deliver these services by itself)
    4. Relined could also offer fibre connections between Amsterdam and Denmark as product
- According to Mrs. Weijers the transit market in the Netherlands is not yet saturated. There is an increasing data demand and an increasing number of companies want to buy data capacity.

Appendix L(1) – Rijkswaterstaat Zee en Delta: Rik Duijts

- Rick Duijts is werkzaam voor Rijkswaterstaat Zee en Delta en hij is nauw betrokken bij de uitgifte van vergunningen voor onderzeese glasvezelkabels naar Nederland

<u>Vergunningprocedure en de betrokken instanties in Nederland:</u>

- Een vergunning voor zeekabel wordt uitgegeven op basis van de 'Waterwet'
- Nederland heeft zich gecommitteerd aan de United Nations Conventions on the Law of the Sea (UNCLOS)
- De Waterwet is van toepassing indien 'er een ingreep plaats vindt in de bodem van de zee'. Voor een dergelijke ingreep is een watervergunning nodig. Deze vergunning wordt uitgegeven door Rijkswaterstaat
- Waterschap en Rijkswaterstaat werken vaak samen om 'één watervergunning' af te geven voor kabels die door de Noordzee lopen en daarna een 'waterkering' over land kruisen
- Er zijn maar een handvol aanlandingspunten waarbij de waterkering wordt gekruist. De reden hiervoor zijn de hoogte van de investeringskosten om een connectie te maken met het backhaul netwerk op het land
- Gemeente moet vaak extra vergunning geven voor het werk op strand, hierbij gaat het voornamelijk om veiligheidsaspecten
- De kustwacht heeft de focus op de vaarbelangen
- Watervergunning 'kan in principe niet worden geweigerd' dit gaat in tegen UNCLOS. Dit verdrag bepaald dat een kabelaar het recht heeft om een kabel te leggen
- Echter, voorwaarden voor een afgifte van watervergunning kunnen zijn:
  - Kies een zo optimaal mogelijke route, met weinig andere gebruikers in de weg zitten
  - Infrastructuur met nationaal belang zoals windparken op zee en gasinfrastructuur gaan voor glasvezelkabels. Deze glasvezelkabelinfrastructuur is in de waterwet niet gedefinieerd als 'nationaal belang'
  - Vaargeulen moeten met een rechte hoek worden gepasseerd. Dit is ook in het belang van partijen zelf. Het repareren van een kabel in de vaargeul is namelijk zeer lastig
  - Gebieden met een speciale functie zoals militairoefengebied, zandwingebieden mogen in principe niet worden doorkruist, tenzij er hierover consensus is met bijvoorbeeld de belanghebbende
- Het hebben van een Crossing Proximity Agreement (CPA) is geen voorwaarde voor een watervergunning. De gedachte hier achter is dat dit niet kan worden afgedongen door de Waterwet, deze behandelt alleen 'functies' in de zee. Eventuele conflicten worden privaatrechtelijk afgehandeld
- Vaak worden het aantal CPAs geminimaliseerd door investeerders, ze zijn duur

<u>Overzicht van beleid en belangen betrokken instanties:</u>

- Veiligheidszone aan beide kanten van een glasvezelkabel is 750m en dit is in lijn met UNCLOS verdrag. Echter na consultatie met KPN is hier voor de beleidsnota Noordzee 2016-2021 van af geweken en is op sommige plekken de veiligheidszone gereduceerd tot 500m aan beide kanten

- Veel discretionaire voor beleidsmakers wat betreft het beleid op de Noordzee. De Waterwet is onspecifiek, dus veel van het beleid wordt specifiek gemaakt via beleidsnota's en prioritaire beleidsnota's
- De nieuwe veiligheidszone van 500m kan door kabelaars worden gezien als problematisch, zij hebben contracten met bedrijven die oudere boten hebben welke de 750m nodig hebben, zoals British Telecom
- Deze afstand is nodig omdat bij een kabelbreuk de positie van de kabel niet exact is te bepalen. Bij een breuk wordt een 'dreg' wordt uitgegooid om de kabel 'te haken'. Dit proces vergt flink veel omliggende ruimte
- Communicatiekabels zijn niet gedefinieerd als nationaal belang voor de Nederlandse wet. Vier tot vijf jaar geleden stelde de sector dat glasvezelkabels schaalbaar zijn en weinig op nieuw hoeft worden aangelegd, door grote aanbod van bestaande glasvezelsinfrastructuur. Sectoren zoals de gasindustrie en de windmolenparkbouwers zijn wel constant in beweging qua aanleg. Daarom zijn deze sectoren getypeerd als 'nieuwe infrastructuur'.
- Bij deze analyse is echter geen rekening gehouden met de grote groei van de vraag naar data meegenomen en het toenemende belang van een lage latency
- Glasvezelsector op zee is niet centraal georganiseerd om belangen te waarborgen in tegenstelling tot bijvoorbeeld de gassector
- Veel glasvezelkabels in zee worden éénmaal aangelegd en kunnen daarna meerdere keren worden doorverkocht
- Op dit moment zijn er geen nieuwe vergunningaanvragen om glasvezelkabels in zee aan te leggen naar Nederland

<u>Barrières voor onderzeese glasvezelkabels naar Nederland</u>

- Een glasvezelkabel kan een windmolenpark op zee doorkruisen als deze is aangelegd voor de aanleg van het windmolenpark zelf
- Er kan geen nieuwe onderzeese glasvezelkabel aangelegd worden door een bestaande windmolenparken heen. Bij eventuele reparatie moet er namelijk een 'extra lus' worden toegevoegd aan de glasvezelkabel, deze past niet binnen bestaande windmolenparken en hun onderhoudsmarges. Deze marge is 600m aan beide kanten bij nieuwe parken.
- Bestaande Windmolen parken vormen dus een barrière voor nieuwe glasvezelverbindingen en dwingen nieuwe kabels richting de vaargeul en met meer omwegen. Dit is voornamelijk een probleem voor kabels richting Amsterdam
- Vergunningen voor windmolenparken bestaan uit grote 'blokken' om versnippering te voorkomen. De Noordzee wordt steeds meer een 'wingebied voor energie'. Dit zelfde verschijnsel is waarneembaar in de omliggende landen
- Waddenzee vormt ook een natuurlijke barrière. Door de constante bewegingen van het zand tussen eb en vloed is er een grote diepte van de kabel nodig in de zeebodem. Op deze manier kan er voor worden gezorgd dat de kabel ingegraven blijft. In het wadden gebied is er een diepte van plusminus 3 meter diepte nodig. Dit maakt de aanleg van een glasvezelkabel door het waddengebied een duur
- Ten Noorden van Nederland moet ook rekening worden gehouden met de militaire oefengebieden. Doorkruising van dit gebied is mogelijk na overleg. Er wordt weinig geschoten
- Het is mogelijk om nieuwe kabels aan te leggen door bestaande windmolen parken als er in deze parken bredere corridors worden aangelegd

- Een beleidsoptie is om een brede corridor aan te wijzen op de Noordzee zodat glasvezelkabels hier doorheen kunnen lopen. Er is echter weinig plaats voor zo een brede corridor, het is zeer druk op zee
- Momenteel zijn er twee al corridors voor de kust van Noord-Holland zodat kabels kunnen worden aangelegd en niet worden geblokkeerd door Zandwingebieden
- Prematuur idee: Leg een 'werkeiland' aan bij 'verre windmolenparken voor de kust', hierbij kan ook een zeer hoge capaciteit datakabel worden aangelegd, waarbij een datacentrum zich op het eiland in zee bevindt. Andere zeekabels hier dan aangesloten kunnen worden. Boskalis vindt dit een interessant idee

Overheidsbeleid voor de ruimtelijke indeling van de Noordzee

- Overheid heeft inconsequent beleid wat betreft de Noordzee:
    - Nederland geeft aan UNCLOS te gebruiken, maar de 750m onderhoudsruimte aan beide kanten die de industrie standaard is wordt niet gevolgd in sommige situaties. Een kabel van British Telecom heeft bijvoorbeeld maar 500m aan beide kanten
    - Huidige allocatie van infrastructuur is gebaseerd op 'wie het eerst komt, wie het eerst maalt'. Dit leidt tot 'rare slingers' in de infrastructuur op de Noordzee
    - Overheid geeft aan dat digitale infrastructuur belangrijk is maar er komen grote barrières voor nieuwe kabels
- Er zou kunnen worden gekeken om meer structuur te geven aan het beleid op de Noordzee. De Noordzee wordt namelijk steeds drukker en daarom is meer structuur gewenst
- Mijn schatting is dat een nieuwe glasvezelkabel door een bestaand windmolenpark zo veel problemen oplevert, dat het in de praktijk niet zal worden gedaan
- Bij het ontwerp van nieuwe parken kan er rekening worden gehouden voor glasvezelkabels door het invoegen van een corridor. Met deze gereserveerde ruimte is doorkruising van een windpark op zee eventueel wel mogelijk
- Met de huidige stand van de techniek is veel ruimte nodig voor reparatie en is de kans op beschadiging van andere kabels groot
- Als reparatietechniek wordt verbeterd zodat de reparatie kan gebeuren zonder kans op schade van andere kabels, dan kom je in een andere situatie. Zo ver zijn we nu nog niet

Conflict tussen de kabelaars en de vissers: De optiek van de vissers

- In de Waterwet is een begraafeis opgenomen voor onderzeese glasvezelkabels. Deze eis varieert van 0.5m bij oude kabels tot 0.8m bij nieuwe kabels in zee
- Door strijken van de tijd komen kabels los te liggen en worden ze kwetsbaar voor netten van de visserij
- Vaak ontstaat schade doordat de kabel niet goed is ingegraven. Daarom zou de schade niet verhaalt moeten worden op de visser
- Schade wordt vaak toch verhaalt op de vissers. Kabeleigenaren verzamelen bewijs met systemen die de vissers monitoren
- De verzekering van vissers moet de schade doorgaans vergoeden
- Daardoor wordt de verzekering voor vissers praktisch onbetaalbaar, door een stijgende premie

- De visserijsector is boos omdat er geen controle is of de kabel is ingegraven. Men vinden dat een losse kabel niet aan de watervergunning voldoet

Conflict tussen de kabelaars en de vissers: De optiek van de kabelaars

- Kabels worden ingegraven, maar zijn onderhevig aan omgeving
- Het monitoren of kabels nog steeds ingegraven liggen is heel moeilijk en zeer kostbaar
- Kabelaars stellen kaarten beschikbaar aan vissers zodat deze niet door onderhoudsgebieden van kabels heen varen
- Vissers doen dit ondanks de waarschuwingen toch en maken op deze manier de kabels kapot
- Kabelaars hebben een systeem ontwikkelde dat vissers monitort en kijken wat ze doen bij de kabels Data van dit systeem kan dienen als bewijslast in rechtszaken

Huidige uitspraak over het conflict en verder overwegingen:

- Rechter geeft kabelaars gelijk. Vissers zijn aansprakelijk bij schade aan een kabel. Hiermee is veel geld mee gemoeid
- EZK zou volgens dhr. Duijts kunnen bemiddelen voor een convenant tussen vissers en kabelaars. Echter er zijn een paar problemen:
    - De groep 'de vissers' is lastig te definiëren. Zij bestaan uit verschillende groepen en er is geen centraal aanspreekpunt
    - De kabelaars zijn niet verenigd en hebben geen centraal aanspreekpunt
- Rijkswaterstaat heeft aangegeven bij vissers dat ze 'losliggende kabels' kunnen melden zodat dit kan worden doorgegeven aan de kabelaars. Tot nog toe zijn er nog nul meldingen gedaan van losliggende kabels
- In Frankrijk kunnen kabelaars de schade niet verhalen op vissers. Dit leidt tot opportunistisch gedrag van vissers. Men kan expres een kabel opvissen om geld te claimen van de kabelaars

Appendix L (2) Translation – Rijkswaterstaat Sea and Delta: Rik Duijts

- Rick Duijts works for Rijkswaterstaat Sea and Delta and is closely involved with the issuance of permits for the construction of submarine fibre cables in the Dutch seas

<u>Permit procedure and the involved institutions in the Netherlands</u>

- A permit for a submarine cable can be issued on the basis of the 'Waterwet' (Water law)
- The Netherlands has committed to the United Nations Conventions on the Law of the Sea (UNCLOS)
- The Waterwet is applicable if a party 'intervenes with the seabed'. For such an intervention a water permit is required. This permit is issued by Rijkswaterstaat
- The Waterboard and Rijkswaterstaat cooperate to create one permitting procedure for both the sea part and the terrestrial flood defence crossing part of the optic cable
- There are only a handful of cable landing points where the flood defence is crossed by a optic fibre. The reason is that the crossing of a flood defence, such as a dyke, to the terrestrial backhaul, requires high investments
- Local municipalities also have to issue a permit for the construction work on the beach. The requirements for these permits are mostly about safety precautions
- The coastal guards mostly focus on the shipping interests
- In principle a request for a water permit cannot be turned down under UNCLOS. This convention defines the right for submarine cable investors to lay a cable through territorial waters
- However additional requirements are in place for the issuing of a water permit. These are:
    - Choose the most optimal route in which there is little disturbance of other users of the sea
    - Infrastructure of 'national interest', such as marine windfarms and gasinfrastructure, have priority submarine optic infrastructure. In the Waterwet submarine communication cables are not defined as a 'national interest'
    - Shipping lanes should be crossed with a right angle. This is also in the interest of the owners of the cable. The repair operations of submarine cables in shipping lanes are very difficult
    - In principle areas with special assigned function cannot be crossed. Examples of such areas are military practice areas, sand extraction areas. Only after permission of the parties of interest a cable can cross such an area
- A Crossing Proximity Agreement (CPA) is not a requirement for a water permit. The Waterwet is not a basis to force this. The law only intents to manage the different 'functions' of the sea. Any conflicts are dealt with under private law

- Usually the number of CPAs is minimalized as much as possible, since they are expensive

Overview of the policies and interests of the involved institutions

- The safety zone on both sides of a submarine fibre is determined on 750m, in line with UNCLOS. However the policy paper 'North Sea 2016 – 2021' reduces the minimum maintenance zone to 500m in certain cases. This was done after consultation with KPN
- Policymakers have a lot of discretionary space for the spatial planning of the North Sea. The Waterwet is quite general and non-specific and therefore a lot of policy comes from policy papers and priority policy papers.
- The new safety zones of 500m can by perceived by submarine owners, such as British Telecom, as problematic. Cable owners have contracts with companies for the repair operations. Some of these companies use an older type of vessel, which require a safety zone of 750m.
- This distance is required because it is not possible to determine the exact position of a cable after a cable cut. For the repair operations of a cable cut a grapnel is used to hook the cable on the seabed. This process requires quite a large space.
- Submarine communication cables are not defined as 'national interest' under Dutch law. Four to five years ago the sector communicated that little new fibre infrastructure was required in the future, since there is a large supply of data capacity and the scalability of the fibre networks. Other industries like the gas industry and the windfarm sector are constantly changing and require constantly new infrastructure. Therefore these industries were defined as 'new infrastructure'
- The previous line of reasoning did not take into account the large growth of data demand and increasing importance of low latency connections
- In contrary to the gas industry, the submarine optic fibre industry is not centrally organized to safeguard their business interests
- After construction submarine fibres can be resold multiple times
- Currently there is no request for the issuance of a permit for a submarine cable that lands in the Netherlands

Barriers for submarine communication cables connections to the Netherlands

- A submarine communication cable can only cross a marine windfarm if the cable was constructed before the construction of the windfarm
- It is not possible to cross an existing marine windfarm with a submarine communication cable. In case of a cable cut an extra 'loop' is placed between the two parts of the cable. In this way the cable will increase in length and will not fit within the existing windfarm without exceeding the maintenance zone. The new windfarms provide a margin of 600m for maintenance between the turbines

- Thus, marine windfarms create a barrier for new submarine communication cables to the Netherlands. They force new cables in the direction towards the shipping lanes and cause sub-optimal routes of the cable. This is especially a problem in the route to Amsterdam
- Permits for future windfarms at sea are issued in large 'blocks' to prevent fragmentation. The North Sea is increasingly an 'energy extraction area'. The same trend is observable in the surrounding countries
- The Waddensea, the sea north of the Netherlands, is a natural barrier. Due to the strong tides there is a constant and strong movement of sand on the sea bed. Therefore the a sea cable has to be buried at lower depth than usual. In this way it can be made sure that the cable will be kept covered by sand. In the Waddensea a bury depth of around 3 meter is required. For this reason the construction of a submarine communication through this area is costly
- On the north side of the Netherlands there is also a military practice area, which has to be taken into account. A through this area can be possible, but requires approval of the authorities. The military zone is rarely actively used.
- It is possible to cross marine windfarms if these designed with a wide cable corridor
- A policy option to keep the Netherlands accessible is to assign a wide cable corridor in the North Sea. However there is little space available for such a corridor
- Currently there are already two cables corridors in front of the shore of Noord-Holland (North Holland) so that cables can cross sand extraction areas
- A conceptual solution: Create a 'artificial work island' close to the windfarms that are the furthest from the shore. A very high capacity optic cable can connect this island with the Netherlands. A datacentre on the island can be the landing point for the submarine cables to the Netherlands. Boskalis, a large dredging company, is interest in this idea

<u>Governmental policies of the spatial planning of the North Sea</u>

- Current policies regarding the North Sea are inconsistent:
    - The Netherlands agreed on UNCLOS, but at the same time it did not agree to keep the minimum maintenance zones of 750m on both sides of submarine fibers, which is the industry standard. Some cables of British Telecom only have 500m of space on both sides
    - Current allocation of the infrastructure is based on a 'first come, first served' basis. This creates 'strange garlands' in the cable infrastructure in the North Sea
    - The government acknowledges that digital infrastructure is important, but at the same time it creates large barriers for new cables
- Perhaps the government should structure the policies more for the spatial planning of the North Sea. The North Sea is getting more and more busy, which requires a more structured approach

- My estimation is that the crossing of an existing marine windfarm with a new submarine fibre will create to many problems to be feasible
- The design of the windfarms could take the interests of the cable owners by reserving space in the form of a corridor. In this way crossings of windfarms can be possible
- With current technology a lot of space is required for the repair of submarine cables and is there a large risk of damaging surrounding cables
- Technology improvements might change this situation, which might impact the optimal policy. However right now this is still not the case

<u>Conflict between the cable owners and the fishermen: The perspective of the fishermen</u>

- The Waterwet determines a minimal bury depth for submarine fibers. This requirements was 0.5 for the older cables and is 0.8m for new cables
- By ironing time the cable could become exposed and will therefore be more vulnerable for damage due to fishing activities
- A lot of times damage of a cable occurs due to the exposure of the cables. For this reason the fishing industry argues that they are not responsible for this damage
- Nonetheless cables owners demand compensation for the damage of their cables from the fishers
- Usually the cable owners is successful in claiming a compensation of the fishers. They have systems that monitor fisherman to collect evidence
- Normally insurance of the fishers reimburses the damage to the cable
- Consequentially the costs of insurances for fishers are rising rapidly and become practically unaffordable
- The fishing industry is furious because there is no proper control for the burial of the cables. According the fishing industry the telecom providers do not comply the Waterwet

<u>Conflict between the cable owners and the fishermen: The perspective of the cable owners</u>

- Cables are buried, but they will be always subject to natural forces
- The monitoring of burry depth of sea cables is very difficult and extremely costly
- Cable owners distribute detailed maps with the location of the cables so that fishers can avoid these areas
- Despite the warning of cable owners the fishermen keep causing cable cuts
- Cable owners developed a fisher-monitoring-system which collects data for which can serve as evidence in lawsuits

Current judgement on the conflict and other considerations

- Dutch judges confirm that the position of the cable owners is correct. Fishers are liable for any damage to submarine fibres, which can be very costly.
- The Ministry of Economic affairs and Climate policy could mediate and create a covenant between fishers and cable owners. However this is easier said than done:
    - There group 'fishers' has no clear definition. They consist of different subgroups and have therefore no central point for contacts
    - The submarine cable owners are no not unified in the Netherlands and therefore do not have a central point for contact
- Rijkswaterstaat informed the fishers that they notify 'loose cables' so that they can be buried by the cable owners. However until now there were zero notifications of unburied cables
- In France cable owners cannot recover the damages from the fishers. Sometimes this leads to opportunistic behaviour of fishers. They catch a submarine fibre on purpose to claim a compensation of cable owners

Appendix M(1) – Saba Statia Cable System B.V.: Werner de Haan

- Dhr. de Haan zit in het bestuur van de SSCS b.v.. Dit is een b.v. die een onderzeese glasvezelkabel aanlegde tussen de bovenwindse eilanden. De Nederlandse staat is de enige aandeelhouder van SSCS b.v.

<u>Externe onzekerheden bij de aanleg van een onderzeese glasvezelkabel</u>

- Seismologische activiteit. Er is onderzoek nodig naar de zeebodem voor de aanleg
- Mogelijk instabiliteit ondergrond, dit kan mede worden veroorzaakt door orkanen in Caribisch gebied
- Kruisingen van een bestaande zeekabel. Hiervoor is een Crossing Proximity Agreement (CPA) nodig. Er moet contact worden gemaakt met de eigenaar van de kabel en bepantsering worden aangebracht op het kruisingspunt

<u>Effect van nieuwe glasvezels</u>

- Nieuwe glasvezel kabels zijn 'zuiverder'. Hierdoor neemt de signaal sterkte minder snel af en zijn over dezelfde afstand minder 'repeaters' nodig. Dit verlaagt de totale kosten van nieuwere kabels.
- Er is bij de keuze voor de kwaliteit van glasvezel een afweging tussen de demping en de totale kosten. Soms is het goedkoper een 'duurdere' vezel te gebruiken voor afstanden kleiner dan 400km zodat er geen versterking nodig. Goedkopere vezels zouden bij afstanden net onder de 400km versterkers nodig hebben en bijbehorende stroom op de kabel voor de energievoorziening. Dat kan duurder uitpakken.

<u>Kosten voor een onderzeese glasvezel kabel</u>

- Tegenwoordig zijn de meeste van de kosten voor de aanleg van een onderzeese glasvezel kabel tegenwoordig is niet meer het materiaal zelf, maar de fysieke activiteiten voor de aanleg. De huur voor een aanleg boot kost bijvoorbeeld zo'n 75.000 euro per dag.
- De aanleg van één extra vezel zorgt voor een kosten toename van ongeveer 10%, dit is dus een klein deel van de totale kosten.

<u>Verschillende soorten verkoopmodellen voor glasvezelconnectiviteit</u>

1. Dark fiber: Verkoop of verhuur van één of meerdere glasvezelkabels. Hierbij is eigen apparatuur nodig. Voor deze oplossing wordt vaak gekozen bij een lange looptijd en veel data. De specificatie van het type glasvezel is hierbij belangrijk. Dit wordt verkocht door Fibercarriers, zoals Columbus.
2. Verkoop van data in een hogere Open System Interconnection laag (OSI-laag). Een service voor data transport inclusief belichting. Bijvoorbeeld het leveren van IP transit capaciteit tussen A naar B waarbij een bepaalde 'latency' en betrouwbaarheid wordt gegarandeerd door de data aanbieder. Dit kan zijn door gebruik te maken van verschillende kabels voor

een data service. Verschillende typen contracten zijn mogelijk bij verschillende mate van verschillende data management in het OSI level.

Nederlandse onderzeese glasvezelmarkt

- Deze markt is voor een groot deel verzadigd door hoge capaciteit en opschaalbaarheid van huidige onderzeese kabelsystemen. Ook is het er concurrentie door de vele glasvezelkabels tussen steden. Via de backhaulnetwerken over land kan er gemakkelijk worden uitgeweken naar andere trans-Atlantische kabels.
- Voor de grote spelers op de markt zijn het goede data tarieven. Voor kleine spelers is het moeilijker om goede tarieven te krijgen.

Huidige Situatie van Nederland

- Tot nog toe heeft Nederland nog een sterke positie in de internetinfrastructuur door AMS-IX en NL-IX.
- Bedrijven kunnen het niet veroorloven om geen kabel naar Nederland aan te leggen.
- Echter een geografische lastige ligging en drukke vaargeulen en de visserij zorgen voor complexiteit voor kabelaars.

Toekomst

- Mogelijk veel kabels van Zuid-Amerika en Amerika naar Portugal en Spanje. Dit maakt het mogelijk dat internet exchanges daar invloedrijker worden. Op deze manier zou Nederland de dominante posities ook op de langere kunnen verliezen. Dit proces is echter nu nog te pareren.
- Belangrijk dat Nederlandse internet exchanges goede deals met CDNs en content and application providers blijven sluiten, zodat de data via Nederland blijf lopen.

Suggesties voor de Nederlandse overheid om de barrières voor nieuwe kabels te verlagen

- Corridor: Een corridor is een beschermende restrictie voor de kabels tegen de andere gebruikers van de Noordzee
    - Dit kan een effectief middel zijn voor de bescherming van kabels tegen vissers met sleepnetten.
    - Verder kan dit ook effectief zijn tegen olietankers die hun ankers uitgooien tijdens een noodstop.
- Windmolenparken**:** Momenteel worden er veel investeringen op zee gedaan. Er zijn synergie kansen voor elektriciteitsbedrijven en kabelaars om samen kabels te leggen en windmolen parken kunnen corridor vormen.
- Loket voor Kabelaars: Richt één centraal informatie punt op waar kabelaars en andere investeerders alle informatie kunnen krijgen voor de procedures en andere relevante zaken om kabels aan te leggen. Over het algemeen lopen Europese aanvragen voor vergunningen vrij gestructureerd en transparant.

- Creëer een punt/eiland in de zee: Zorg dat er bij de aanleg van windmolenparken een corridor komt met veel glasvezels naar een centraal punt in de zee buiten de vaargeulen. Hier kunnen dan nieuwe partijen makkelijk aanhaken als ze willen investeren in kabels naar Nederland
- Faciliteer samenwerking kleine partijen: Zorg dat kleinere operators samenwerken om te kijken of het in de toekomst mogelijk is om investeringen te doen in communicatiekabels naar het buitenland vanuit Nederland

Trends in de markt

- Telecomproviders hadden de mogelijkheid om samen kabels aan te leggen met partijen zoals Google en Facebook.
- Traditionele telecomaanbieders bleven te veel denken in de traditionele telecomgedachten, waarbij telecom is apart afgebakend is.
- Er ontstonden te hoge kosten voor Microsoft, Facebook, Google om data uit te wisselen tussen hun datacenters
- Dus leggen deze partijen nu zelf kabels aan en is de macht over data capaciteit nu buiten 'Nederlandse partijen'. Volgens dhr. de Haan is dit een gemiste kans.
- Partijen als Level 3 zijn een capaciteitsbroker voor restcapaciteit. Deze bedrijven kopen oude capaciteit op en verkopen deze door.

Probleem huidige telecomproviders

- Doordat Facebook, Google en Microsoft nieuwer soorten glasvezel, protocollen en belichtings-apparatuur gebruiken voor hun onderzeese glasvezelkabels hebben hun kabels een lagere latency.
- De telecombedrijven beginnen steeds verder achter te lopen en daarom moeten bestaande onderzeese kabels sneller worden afgestoten.
- Partijen in Nederland zouden moeten samenwerken met grote partijen om nieuwe investeringen naar Nederland te halen.

Huidige strategie Nederland

- Nederland past belastingklimaat aan om de datacenters van grote partijen te lokken, op deze manier wordt Nederland toch goed ontsloten omdat deze partijen data naar Nederland toe moeten krijgen. Dit creëert een duidelijke 'pull-incentive' voor investeerders in onderzeese infrastructuur.

Appendix M(2) Translation – Saba Statia Cable System B.V.: Wener de Haan

- Mr. de Haan is board member of the SSCS b.v. This company managed the construction of a submarine communication cable between the Windwards Islands that are part of the Kingdom of the Netherlands. The Dutch national government is the only stakeholder in the company.

<u>External uncertainties that are involved with the construction of a submarine communication cable</u>

- Seismological activity. The seabed should be examined before the construction of a cable
- Possible instability of the ground, which can be caused by hurricanes in the Caribbean.
- A crossing of a new cable with an existing submarine cables. A Crossing Proximity Agreement (CPA) is required for the crossing. The constructing party contacts the submarine cable owner. Armor is added to the cables in the crossing.

<u>Effect of new optic fiber materials</u>

- New fibers have a higher 'purity'. Therefore the dispersion of the signal is lower which reduces the damping of the signal. This reduced the required amount of repeaters for a certain distance. Therefore the total costs for new submarine communication cables are lower.
- The choice for the quality of the fiber is a trade-off between the level of damping and the total costs. Sometimes it is cheaper to choose the more expensive fiber material for distances below the 400km so that no signal repetition is required. The choice for cheaper fiber material for distances just below the 400km might require submarine optical amplification, which requires power on the cable as power supply. This might be more expensive.

<u>Costs of the construction of a submarine communication cable</u>

- Nowadays the majority of the costs of the construction of a new submarine communication cable do not consist of the material, but the physical activities for the construction itself. The rent of a vessel that can deploy a submarine cable can easily be 75.000 euro a day.
- The addition of one extra fiber would lead to an increase of costs of about 10%. This is a relative small part of the total costs.

Business cases for optic fiber connectivity

1. Dark fiber: The sales or rent of one or more fibers in a submarine communication cable. The data users has to place own sending and receiving equipment to 'lid' the fiber. The solution is chosen when long term data transit is required and in case of large quantities of data transit.
2. The sales of data transit services in a high 'Open System Interconnection' layer (OSI-layer). This is a data service including 'lighting' of the fiber. For example with an IP transit service the telecom provider offers data capacity between point A and B including guarantees for latency and reliability. A telecom provider can guarantee this through the use of different cables for one data service. Different types of contracts are possible for different data services, depending on the OSI layer.

The submarine fiber market in the Netherlands

- This market is saturated to a large extend due to high existing capacity and the scalability of the current submarine communication cables. Extra competition is created due to the large number of optical fibers between the large European cities. Other trans-Atlantic fibers can be reached through these terrestrial backhaul networks.
- For large data users it is easy to buy data transit for competitive prices. On the contrary smaller data users might have difficulties.

Current situation of the Netherlands

- Currently the Netherlands has a strong position in the internet infrastructure because of the existence of the AMS-IX and the NL-IX.
- Telecom providers cannot afford to not have a cable to the Netherlands
- However the geographical position, the busy shipping routes and fishing activities create complexity for the cable owners

Future

- In the future more submarine communication cables might be constructed between South-America and the United States to Spain and Portugal. If this happens the internet exchanges in these countries might be become more influential. It is still possible to ward of this process
- It is important that Dutch internet exchanges keep making deals with CDNs and CAPs. This how the Netherlands can stay ahead of the competition

Suggestion for the National government of the Netherlands to reduce the investment barriers for submarine communication cables

- Corridor: A corridor might be an effective way to protect submarine cables through restriction of other users of the sea
    - It can protect cables against cable cuts due to fishing activities.
    - A corridor might also be effective to protect cables from oil tankers that use anchors during emergency stops.
- Windfarms: Currently there are a lot of investments in projects at sea. There might be synergy opportunities between electricity companies and telecommunication providers that want to invest in submarine communication cables. Windfarms at sea can create a corridor for cables
- A central organization for cable investors: Create an organization that can help investors in submarine communication cables to obtain the right information regarding required the procedures and other relevant information for the construction of submarine cables. In general permit procedures are quite structured and transparent in Europe.
- Create an island at the coast of the Netherlands: Make sure that there is a cable corridor in the windfarms that connect the Netherlands with an artificial island outside the shipping routes. Future investments in cables to the Netherlands can be connected to this island.
- Facilitate collaboration between smaller investors. Make sure that small operators have the opportunity to collaborate and joint-invest in submarine communication cables to the Netherlands

Market trends

- In the past telecom operators had the possibility to collaborate with companies as Google and Facebook to invest in new cables
- The traditional telecom providers kept thinking in 'traditional telecom paterns', thinking that telecommunication a separate activity
- Due to this situation Microsoft, Facebook and Google payed high prices for the data exchange between their data centers
- Therefore they started to construct own cables, which shifted the power of data transit capacity outside 'the Dutch infrastructure owners'. According to Mr. de Haan this is a lost opportunity

Current problems of telecom providers

- Facebook, Google and Microsoft use newer types of fiber material for their cables. Furthermore they use more efficient protocols and better sending and receiving devices. This is the reason that their cables have a lower latency.

- The telecom providers start to lag more and more behind the CAPs in terms of submarine communication cables. Therefore they have to amortize their assets more rapidly than expected
- Infrastructure investors in the Netherlands should work together with large companies to attract new investments to the Netherlands

Current strategy of the Netherlands

- The Dutch government has adjusted its tax-climate to attract companies to open a data centers in the Netherlands. In this way companies are forced to transfer their data to the Netherlands, which creates an 'pull-incentive' for investments in submarine communication cables that land in the Netherlands

Appendix N- Interview Telefónica/Telxius: A. Moreno Rebollo

Background information: Telxius is a company created by Telefónica which owns and manages the telecom infrastructure. The main objective of Telxius is to capture the value of the increasing data demand worldwide

<u>Procedure for submarine communication investments</u>

1. Telxius contacts or is contacted by third parties to invest in a cable
2. Business case is made with estimations of data demand, revenues, costs and profits based on proposed route.
3. Internal in the company a green light has to be given by directors to use CAPEX funds for investments in a new cable
4. Agreement with the consortium is made
5. Supplier(s) for cable, amplifier, maintenance and construction are contracted
6. Exact cable route is determined
7. Notification to owners of that cables that will be crossed and gas/oil pipe owners (following the ICPC), but CPA (Crossing Proximity Agreements) not compulsory
8. Application of permits at the Spanish government (3 permits required all with different requirements)
    a. National government permits (National Telecom Authority)
    b. Regional government permits (Environmental requirements, which are hard to meet)
    c. Local government permits (Possible difficulties with conditions: political pressure because of elections, tourist interests, special requirements for government e.g. free connection with municipality)
9. Construction phase of the cable (total construction (preparations included) time 3 to 4 years)

<u>Stakeholder for the construction of a Submarine cable</u>

- Governmental institutions
- Fishermen
- Oil, Gas industry, Energy suppliers
- Consortium
- Internal policies of Telxius
- Hard and Software suppliers

<u>Considerations for route</u>

- Focus on having a latency as low as possible (MAREA cable was landed in Bilbao because the Basque Country has good low latency fibre connections with the hub Madrid)
- Land close to backhaul connections that are close to the shore (connection from the beach to the backhaul networks is the most difficult job) and which are good accessible by fibre on land.
- Land close to datacentres, datacentres are the main drives of the growth of transit traffic and therefore it is important to connect with them with a low latency
- Land on a place where there is very reliable energy supply, submarine cables require very high reliability

- Boat routes and current cable and pipe infrastructure
- Environment factors: shape of the ocean floor, chances of earthquake, tsunami etc.
- Find a beach, beaches are the ideal location to land the cable (however only in the winter the construction work can be executed due to tourists interests)
- Choose a different route then the other cables for two reasons (spread):
    1. A different route adds value and options for clients
    2. Route differentiation make the submarine network more robust against the environments (tsunami's, earthquakes)
- Political situation in landing area (lower in priority than latency), problems might arise for permit during election times? (government might add extra special prerequisites)

Business model of Telxius

- Investments: 'Wait and see' after the MAREA cable. The company will monitor the data demand developments and the digital landscape. Possible they will do new investments in the future for connections with Spain.
- New cables have an economic/technical life expectancy of 25 years
- Since the Columbus III upgrades can be done by change the dry equipment (thanks to optical amplifiers), the new systems are very flexible and easy upgradable

- MAREA cable had two drivers:
    1. Fast growing capacity demand of transit data (because of datacentres), Columbus III could not meet the data demand. Marea has a very large capacity
    2. Launch of Telxius as separate entity --> MAREA cable shows the market that Telxius is a reliable and experiences partner
- MAREA cable are very large sunk costs, therefore Telxius is eager to sell as much as transit traffic as possible (different levels of OSI model possible --> OTT services, Spectrum, Flexible bandwidth Services etc.), according to Telxius 'You cannot be conservative', you have to make the cable profitable
- Focus of Telxius is on 'Co-opetition', working together with other telecom companies/ tech-companies to invest in new cables and maintain and operate them together, but at the same time compete on the interconnection market. (Consortium model is still viable)

Most important barriers for a cable construction:

- Connecting the cable form the beach to a low latency backhaul network. This is difficult because of environmental protection legislation, politics and possible long distances between the beach and a backhaul network
- The required investments are very large, the company itself has to apply the internal regulations to decide whether to invest in cables
- The problems for the construction of submarine cables are mostly the 'dry-side' of the submarine cable system, the problems in the sea are mostly because of earthquakes, tsunami's and underwater landslides and boats
- In South America (such are Puerto Rico) there are only 6 weeks available because of the Hurricane season, very small window of opportunity. Also it can be hard to deal with the local politics to obtain permits

Appendix O(1) Original – Interview met Verizon: dhr. Booi

Aanlandingspunten in Nederland

- In het verleden had KPN een kabel tussen Domburg en Engeland. Deze is maar een paar jaar 'online' geweest want er waren zeer veel breuken. Ten zuiden van Rotterdam is er te veel zandverplaatsing (Duingebieden), waardoor kabel bloot komt te liggen.
- Katwijk, Beverwijk, IJmuiden (als er rekening wordt gehouden met kabels in de windparken d.m.v. corridor, alle commerciële partijen zijn aanwezig in IJmuiden) en Eemshaven (echter hier misschien ook op termijn Nederlandse en Duitse windmolens) wel geschikt
- AC1 loopt vanaf Beverwijk via de UK naar de USA, TAT14 land in Katwijk, Ulysses vanaf IJmuiden naar UK
- Lage latency naar Amsterdam zijn Atlantic Crossing 1, Hybernia express (door UK)
- Landingen ten noorden van Egmond niet aantrekkelijk door sterkere stroming en de vaargeul
- De meeste nieuwe transatlantische kabels worden aanngelegd voor verkeer tussen data centers. Op het europese continent heeft Amsterdam de meeste data center capaciteit sinds 3Q2017. Dit kan leiden tot interesse in nieuwe verbindingen tussen wet-Nederland en de VS.

Houding Economische zaken omtrent windmolenparken

- Economische zaken gaat er vanuit dat kabels kunnen worden 'gestapeld', dit is echter niet het geval.
- Corridors zijn niet optimaal. Het is waar dat in corridors niet gevist mag worden, maar tijdens een storm kan hier wel een schip verschillende kabels breken met het anker
- Huidige beleid van 500m aan beide kanten te krap
- Turbine blad zijn tegenwoordig zo groot dat dit ook een factor is waar rekening mee gehouden moet worden. Ze zouden stilgezet moeten worden bij reparaties voor extra ruimte en om de veiligheid van de bemanning te garanderen (grootte wieken is een belangrijke parameter)

Belangengroepen

- ESCA organisatie waarbij alle Europese Telecom operators samen werken
- ICPC wereldwijde belangenbehartiger, NASCA voor Noord-Amerika
- Wereldwijd worden door partijen dezelfde maten aangehouden

Nodige afstand tussen zeekabelkabels

- Verizon houd aan 2,5 keer de waterdiepte tot 3 keer water diepte als afstand tussen kabels (per ICPC recommendations). Deze afstand is nodig om bij het snijden van een kabel met een "grapnel" niet de verkeerde kabel te raken.
- Ruimte is nodig bij een kabelbreuk, als een kabel gebroken is moet er worden gekeken welke kabel die van Verizon is. Hiervoor wordt een ROV gebruikt, hiervoor is het makkelijker als kabels uit elkaar liggen, dan kan er gerichter gezocht worden.

- Versterkte kabels kunnen eenvoudiger worden getraceerd, want er loopt koper door, waarop wisselspanning geplaatst kan worden, wat door het repearatie schip gedetecteerd kan worden. Onversterkte kabels, 7 van de 12 die in Nederland landen, hebben die mogelijkheid niet.
- Bij TAT14 is dit proces gemakkelijker. Bij een breuk wordt er wisselspanning op het koper in de kabel gezet, zo kan deze gemakkelijk worden gedetecteerd door een repareerschip.

<u>Strategische overwegingen:</u>

- Veel oudere transatlantische kabels landen in meest westelijke punt van de UK, dit is Land's end'. Vanuit hieruit loopt veel capaciteit over land direct door UK naar Nederland
- Echter laatste tijd meer een trend om Engeland te vermijden
- Nieuwe plannen trans-Atlantische kabel is om rechtstreeks vanuit New York naar Bordeaux. Vanuit hier makkelijke toegang naar Marseille. Marseille is zeer belangrijk als knooppunt naar India, Midden oosten en Singapore. (via onderzeese glasvezels)
- Laatste jaren focust het verkeer zich meer en meer op het verbinden van datacenters met zo min mogelijk vertakkingen.
- Een trans-Atlantische glasvezelkabel met aftakkingen vanuit de UK (bijvoorbeeld Serpent kabel) is niet logisch vanuit een economisch standpunt (BU ROADMS zijn zeer kwetsbaar in ondiep water, kunnen moeilijk gerepareerd worden (3 kabels, vaak ingegraven), en er zijn lage lease prijzen voor data verkeer over land binnen Europa)
- Binnen Noordzee is het te makkelijk om deze punten bereiken voor duikers, vissers, ankers
- Aftakking wel mogelijk bij bijvoorbeeld een nieuwe kabel vanuit Amerika naar Bordeaux. In een dergelijke kabel zou een aftakking naar Ierland een nieuwe markt aanboren. Dan zou dit wel economisch haalbaar zijn. De branching unit kan dan in diep (>1 km) water gelegd worden.
- Veel Europese aftakkingen zouden alleen voor politieke redenen aantrekkelijk kunnen zijn, (echter markt is geliberaliseerd) maar dit is niet het geval
- Westerse bedrijven hebben geen toegang in China dus daarom is capaciteit duur in China
- Aftakkingen wel mogelijk bij connecties met landen die politieke onrust hebben (Taiwan, Japan)
- In Azië zijn alleen Tokio, Singapore en Hong Kong echt interessant om in te investeren. (enige toegang Maleisië en Vietnam voor halfgeleider productie)
- Strategie van Verizon is te investeren in het verbinden van grote economische centra met kabels ('doel is niet om heel de wereld te verbinden')
- TAT14 is een kabel met ringprotectie, kabel is aangelegd met politieke overweging maar veel kabelbreuken in het intra-Europese deel
- De enige upgrades van de TAT14 zijn in de trans-Atlantische deel, want data via land goedkoper intra Europa.
- Intra Europese van TAT14 tussen Katwijk en Frankrijk wordt veel geraakt. Wordt waarschijnlijk vervangen naar landconnectie.
- West-Europe compleet geliberaliseerd, kan dus het beste gezien worden als één gebied. Met lage over land lease kosten

Verizon ziet Bordeaux aantrekkelijk landingspunt voor Verizon

- Zandstranden, kabels kunnen makkelijk ingegraven worden
- Geen Rotswanden
- Ver genoeg van Calais vandaan waar veel vissers in het kanaal actief zijn
- Makkelijk aansluiten op 'Node' Marseille via backhaul-verbindingen via land

Nederlandse positie bezien binnen de West-Europese markt

- Een eventuele directe kabel naar Amsterdam zou via het Noorden van Schotland richting Amsterdam lopen
- Amsterdam zou een betere kandidaat zijn dan de Scandinavische landen, want deze hebben een relatief kleine markt (weinig inwoners), meer mensen wonen zuidelijker
- Voor Amsterdam is het niet van direct commercieel belang om een directe trans-Atlantische kabel te hebben, West Europa heeft verschillende trans-Atlantische kabels die goed verbonden zijn met Amsterdam via glasvezelkabels over land. Amsterdam blijft dus goed ontsloten via deze andere zeekabels (Intra-Europese deel van TAT14 is niet geupgrade sinds 2001)
- Trans-Atlantische zeekabel is wel goed voor het vestigingsklimaat rond Amsterdam
- Reden om een directe kabel tussen Amsterdam en USA te hebben zou eerder van politieke aard zijn (zie volgende deel)
- Eén van de redenen waarom Google zijn datacentrum in Eemshaven heeft gebouwd was de kabel van TATAcommunications naar de UK. De belangrijkste reden was de beschikbaarheid van veel electriciteit.
- Meeste data verkeer gaat via de kanaalrunnel tussen vanuit Calais naar Folkstone en van daar uit via land naar een Trans-Atlantische kabel
- Nieuwste lage latency kabel is de Hybernia Express tussen de UK en de USA die loopt over het continentale plat van Canada. Deze route werd ook gebruikt door de eerste telegrafie kables. Deze route werd beschouwd als risicovol omdat er in het verleden veel visserij was en veel geologische activiteit. Tegenwoordig zijn er weinig vissers meer door de overbevissing, maar vormt geologische activiteit zoals onderwater landverschuivingen en aardbevingen nog wel een risico. Echter er zijn al geruime tijd geen aardbevingen meer geweest en daardoor wordt er weer geëxperimenteerd om een kabel over dit traject te laten lopen
- Een lage latency kabel direct naar Amsterdam zou ook over het Canadese continentale plat moeten gaan

Invloed van de politiek

- Capaciteit van (onderzeese) backhaul-verbindingen wordt afgetapt in de UK, zie Snowden onthullingen
- Overheden willen mogelijk verbindingen met bondgenoten die niet worden afgetapt door andere landen.
- Brexit maakt dus mogelijk Amsterdam aantrekkelijker voor een kabel direct naar de USA om Engeland heen, zodat deze niet kan worden afgetapt.
- Frankrijk en Duitsland hebben nog grote belangen in respectievelijk Orange en Deutsche Telekom, via deze bedrijven zou politieke sturing bijvoorbeeld kunnen plaatsvinden.

Risico's door ankers en netten

- Verizon heeft een stichting opgezet met middelen van Verizon voor de lokale vissers aan de West-coast van de USA. Als tegenprestatie lobbyen vissers bij andere zee-gebruikers om voorzichtig om te gaan met de kabels bij California en Oregon en verspreiden ze informatie over de locatie van de kabels (preventief beleid). Dit heeft ertoe geleid dat deze kabels al 15 jaar geen breuken hebben gehad.
- In Europa en op veel andere plekken is het scheepverkeer veel internationaler dus is dit model niet mogelijk. Hier worden AIS trackers gebruikt om (vissers)boten te monitoren als ze dichtbij een kabel varen of hier tot stilstand komen. Als dit laatste het geval is wordt er direct contact opgenomen met de lokale kustwacht en wordt bij kabelbreuken de (vissers)boot verantwoordelijk gesteld en moet de verzekering betalen
- AIS trackers in een bepaald gebied kan het aantal breuken van een kabel met een factor 3 laten dalen door tijdig te waarschuwen. AIS werkt afschrikwekkend omdat boten verantwoordelijk kunnen worden gehouden, dus men is voorzichtiger.
- Bijvoorbeeld een schip voer van Istanboel naar Catania terwijl het anker over de zeebodem gesleept werd. Veel kabels in de Middellandse Zee werden zo kapot gemaakt. Via de AIS tracker werd het schip geidentificeerd en toen deze in de haven van Catania aankwam, werden de logboeken in beslag genomen door de politie en werd de eingenaar verantwoordelijk gesteld.
- Meeste kabelbreuken worden nu veroorzaakt vissers en door ankers. Het laatste nabij kabels is slechts toegestaan tijdens bijv. een storm, volgens de internationale scheepvaart wetten voor de veiligheid van de bemanning.

Business model Verizon

- Klein deel is lease van darkfiber, bijvoorbeeld fiberpairs van de Ulysses zijn geleased aan KPN.
- Totale internationale dataverkeer bestaat voor 50% uit IP verkeer en voor 50% uit niet-IP verkeer. De marge op private-IP en OTN interfaces is veel hoger dan op 'wholesale' IP verkeer'.
- Hierom richt Verizon zich voornamelijk op producten zoals OTN verkeere. Dit zijn bijv. End-to-End encrypte services.

Different business cases of Transit Providers:

1. Verizon: Focus op private-IP/OTN interfaces met speciale voorwaarden zoals encryptie, maar ook cloud-producten
2. Wholesale transit providers (zoals Level3): Verkoop van grote volumes met lage marges. Volgens dhr. Booi valt er met dit business model weinig te verdienen.
    a. In het verleden heeft Level3 goedkoop kabels opgekocht om data te verkopen tegen een concurrerend tarief. Ze hebben ook zelf een trans-Atlantische kabel aangelegd de AC2 samen met GlobalCrossing. Hier is GlobalCrossing echter falliet op gegaan
    b. Andere Wholesalers zoals het voormalige Tyco Global Network (TGN) had 4 miljard dollar geïnvesteerd in nieuwe kabels, deze werd uiteindelijke voor 130 miljoen dollar verkocht aan TataCommunications. Deze hebben volgens dhr. Booi zelfs ook nog weinig verdient op de kabel.
3. Google, Facebook, Microsoft en Amazon: hun primaire verdienmodel ligt buiten de onderzeese glasvezelkabelindustrie. Echter in de laatste jaren zijn ze zelf begonnen met het

aanbieden van Clouddiensten en applicaties over eigen netwerken. Dit heeft geleid tot investeringen in zeekabels, eerst het lease van dark fiber pairs op bestaande kabels, de laatste jaren via het kopen van fiber pairs op nieuwe kabels.

Algemene beschouwing toekomst

- Eind jaren 90 is er veel capaciteit aangelegd tussen America en Europa. Maar in 2001/2002 was er een grote crash. Waarbij bleek dat er veel te veel capaciteit trans-Atlantisch was aangelegd. Hierdoor zijn prijzen op dit traject nog zeer competitief en is er nog veel capaciteit. obenut Alleen projecten zoals de TAT14 waren financieel bestending omdat het risico verdeeld was. Veel provate cables gingen failliet.
- Nu worden weer veel kabels aangelegd voornamelijk bij Azië in de Stille Oceaan. Dhr. Booi verwacht dat dit weer leidt toch een bubbel. Deze hoeveelheid transit data is niet nodig door de regionalisering van data door middel van Content Delivery Networks. 'Men is overmoedig aan het investeren'.

Appendix O(2) Translation – Interview with Verizon: Mr. Booi

<u>Landing points in the Netherlands</u>

- In the past KPN owned a cable between Domburg and Great Britain. The cable was only a couple of years operational and was taken out of service rapidly. There were to many cable breaks due to high rates of sand displacement in the area below Rotterdam. The sand displacement exposed the cable.
- Katwijk, Beverwijk, IJmuiden are suitable landing sights (only if with a corridor room is created through the windfarms at sea). Ijmuiden is an interesting connecting point, because all the commercial actors are located over here. The Eemshaven is also an interesting landing sight, but new Dutch and German windfarms could block the route.
- AC1 connect Beverwijk through the UK to the USA. TAT14 cable comes to shore in Katwijk, Ulysses connects Ijmuiden and the UK
- Lowest latency connection between the USA and Amsterdam is through the Atlantic Crossing1 and the Hybernia Express (through the UK)
- Landing points to the North of Egmond are not attractive because there is a strong current in the fairway
- Most new trans-Atlantic communication cables are constructed to connect data centres. Amsterdam has most of the data centre capacity on the European mainland since Q3 2017. This might be a driver for new connections between 'wet-Netherlands' and the USA.

<u>Current policy of the Ministry of Economic Affairs and Climate Policy of the Netherlands</u>

- The ministry assumes that communication cables can be 'stacked'. However this is not possible in reality.
- Corridor are not 'the perfect solution'. Although it is true that fishing is not allowed, harm can be done to by anchors of ships during storms.
- Currently the ministry allows 500m maintenance zone on both sides of a communication cable, this is too narrow in practice.
- The blades of a turbine of a windmill at sea are increasing in since. Therefore the blades have to be taken into account for the determination of the maintenance zones around submarine communication cables in windfarms at sea. (Size of the blades is an important parameter)

<u>Interest groups of the Telecom Carriers</u>

- ESCA is the organisation of all the European Telecom Carriers/operators
- ICPC is the global organisation of Telecom carriers, NASCA is the North-American
- Globally the same guidelines/directives are applied by the different organizations

<u>Required distance between submarine communication cables</u>

- Verizon's own guidelines require cables to have at least 2.5 to 3 times the water depth as minimum distance between submarine communication cables. The reason for this distance is that during recovering activities a grapnel must be used without harming other cables.
- When using a ROV to determine which cable is from Verizon it is also important to have the required space between the cables. The larger the separation between the cables the easier it is to find the broken cable.

- Reinforced cables is easier to track down since it contains copper. An alternating voltage can be put on the cable and tracked down by a sensor on the repair ship. Cables which are not reinforced, this are 7 of the 12 cables that land in the Netherlands, do not have this option.
- The TAT14 is easy traceable since a cable break can be easily found by putting alternating voltage on the cable.

Strategic considerations

- Most of the older trans-Atlantic cables land in the most western point of the UK, which is called Land's end'. From here the signal is guided over land through the UK towards the Netherlands.
- Lately there is a trend to avoid the UK
- New plan for a trans-Atlantic cable is to connect New York directly with Bordeaux, France. From here there is easy access to Marseille. Marseille is an important node with connection to India, the Middle-East and Singapore (through submarine cables).
- In the last years submarine cables aim to connect datacentres directly with as little branches as possible.
- A new trans-Atlantic optic fibre cable with branching units in the UK (for example 'the Serpent cable' proposition) are not logical from an economic perspective. BU ROADMS (underwater branching units) are vulnerable in shallow waters and are very hard to repair. Therefore BU ROADMS require at least three cables to be dough in, which is expensive. Also there are low lease alternatives over land in the mainland of Europe.
- In the North Sea BU ROADMS are vulnerable for fishermen, divers and anchors.
- The use of a branching unit could be economic feasible for a cable between the USA and Bordeaux. Such a cable could have a branching unit with a branch to Ireland. In this way you can tap into a new market. This is possible because the sea is deeper than 1km.
- The only possible reason for a cable with branches to different European countries are from a political nature. However the market is liberalised and therefore this is unlikely.
- Western companies do not permission to construct submarine communication cables to China and therefore capacity is expensive in China.
- Branching units are also used to connect countries that with political tension between them (e.g. Taiwan, Japan)
- In Asia only Tokyo, Singapore and Hong Kong are interesting for investments. (Malaysia and Vietnam are partly accessibly because of their semiconductor industry)
- The strategy of Verizon is to invest in the connection between large economic centres. Unlike other companies the strategy is not to 'connect the entire world'.
- TAT14 is a cable with ring protection and is constructed with political considerations. However in the intra-European part there are a lot of cable failures and breaks.
- The upgrades for the TAT14 are only for the trans-Atlantic part of the cable. The intra-European part of the cable cannot compete with terrestrial connections, which are cheaper.
- The connection of the TAT14 between Katwijk and France is very sensitive for cable cuts. It is likely that this part of the cable will be displaced by a terrestrial connection.
- The West-European market is completely liberalised and therefore can be seen as 'one market'. Lease cost for terrestrial communication fibers are low.

Verizon sees Bordeaux as an attractive landing point

- It has sand beaches, which make it easy to dig in the cables
- There are no rocks walls to pass

- Bordeaux has the required distance from Calais. (Close to Calais there are a lot of fishers)
- There is easy accessibility to the Node Marseille through terrestrial backhaul connections.

<u>The position of the Netherlands in the West-European market</u>

- A direct cable between Amsterdam and the USA would pass the North of Scotland
- Amsterdam might be a better candidate for a trans-Atlantic cable connection than the Scandinavian countries, because Scandinavian countries have a relative small data market (low number of inhabitants). In the south there live more people.
- For Amsterdam there is not a direct commercial interest to have a direct trans-Atlantic cable connection. West-Europe has a number of trans-Atlantic cable with the USA. From these cable there are terrestrial backhaul connections to Amsterdam. Therefore Amsterdam will stay well-connected through other submarine communication cables independent of cables that land in the Netherlands (As said the intra-European part of the TAT14 is not upgraded since 2001)
- Nonetheless a landing of a trans-Atlantic communication cable is good for the business climate in the area of Amsterdam
- A possible reason to construct a direct cable between Amsterdam and the USA is of a political nature (explained in the next part)
- One of the reasons why Google build its datacentre in the Eemshaven is the cable of TATAcommunications. This cable connects the Eemshaven with the UK. The most important reason was the abundance of electricity in the Eemshaven.
- Most of the traffic between the mainland of Europa and the UK runs through the canal tunnel between Calais (France) and Folkstone (UK). From here it can flow further through the UK to the USA.
- The newest low latency cable is the Hybernia Express between the UK and the USA which runs across the continental shelf from Canada. This route was also used for the first telegraph cables. However the route was considered as risky because of the heavy fishing and high geological intensity. Nowadays the number of fishers decreased sharply due to overfishing, but events such as submarine landslides caused by geological activity still poses a threat to cables. But for a long time there has not been any earthquake and therefore there are experiments right now with cables on this route.
- A direct low latency cable between Amsterdam and the USA would go across the Canadian continental shelf.

<u>Influence of politics</u>

- Submarine cable connections are tapped by the UK government (see Snowden-files)
- Governments want to have connections with allies which are not tapped by other countries
- Brexit change the investments in submarine communication cables between the USA and mainland of Europe. Amsterdam might become more attractive for non-tapped cable between the mainland of Europe and the USA which is non-tapped.
- France and Germany have large influence/interest in respectively Orange and Deutsche Telekom. Through these companies they could influence the investment directly.

<u>Risks of anchors and fisher nets</u>

- Verizon has set up and invested in a foundation for local fishers of the west-coast of the USA. In return the fishers lobby other users of the sea to be precautious for the submarine communication cables that are close to the state of California and Oregon. They also share information of the location of the cables with other users of the sea (precautionary policy). This policy is effective, there have not been any cables break for over fifteen years.

- In Europe and other busy areas there is too much international sea traffic and therefore this policy will not work. Instead carriers use AIS trackers to monitor fishers at sea. Coast guards are informed if a fisher boat stops close to a cable. In case of a cable break because of the behaviour of the fisher boat the fishers can be held liable. The telecom carrier then can put a claim on the insurance of the fisher.
- AIS trackers in an area can reduce the amount of cable breaks with a factor three, if warnings are send timely. AIS works preventive because vessels can be held responsible for cable break and therefore they will be more careful.
- For example: A vessel sailed from Istanbul to Catania with the anchor down on the seabed. A large number of submarine communication cables in the Mediterranean were harmed. With help of the AIS tracker the vessel could be identified. As soon as the boat entered the harbour of Catania, the logs of the boat were confiscated by the local police. The owners could be held liable.
- Most of the cable failures are caused by fishermen and anchors. Anchors will remain a problem because according to international shipping law for the safety of the crew it is permitted to lower the anchors during storms regardless of cables in the sea.

Business case Verizon

- A small part of the infrastructure of Verizon is leased as dark fibre. For example some fibre pairs of the Ulysses are leased to KPN.
- The international data traffic is consists of roughly 50% IP traffic and 50% non-IP traffic. The margin of private-IP and OTN interfaces is much higher than 'whole sale IP-traffic'
- Therefore Verizon focusses on specific services such as OTN traffic. Examples are End-to-End encrypted services.

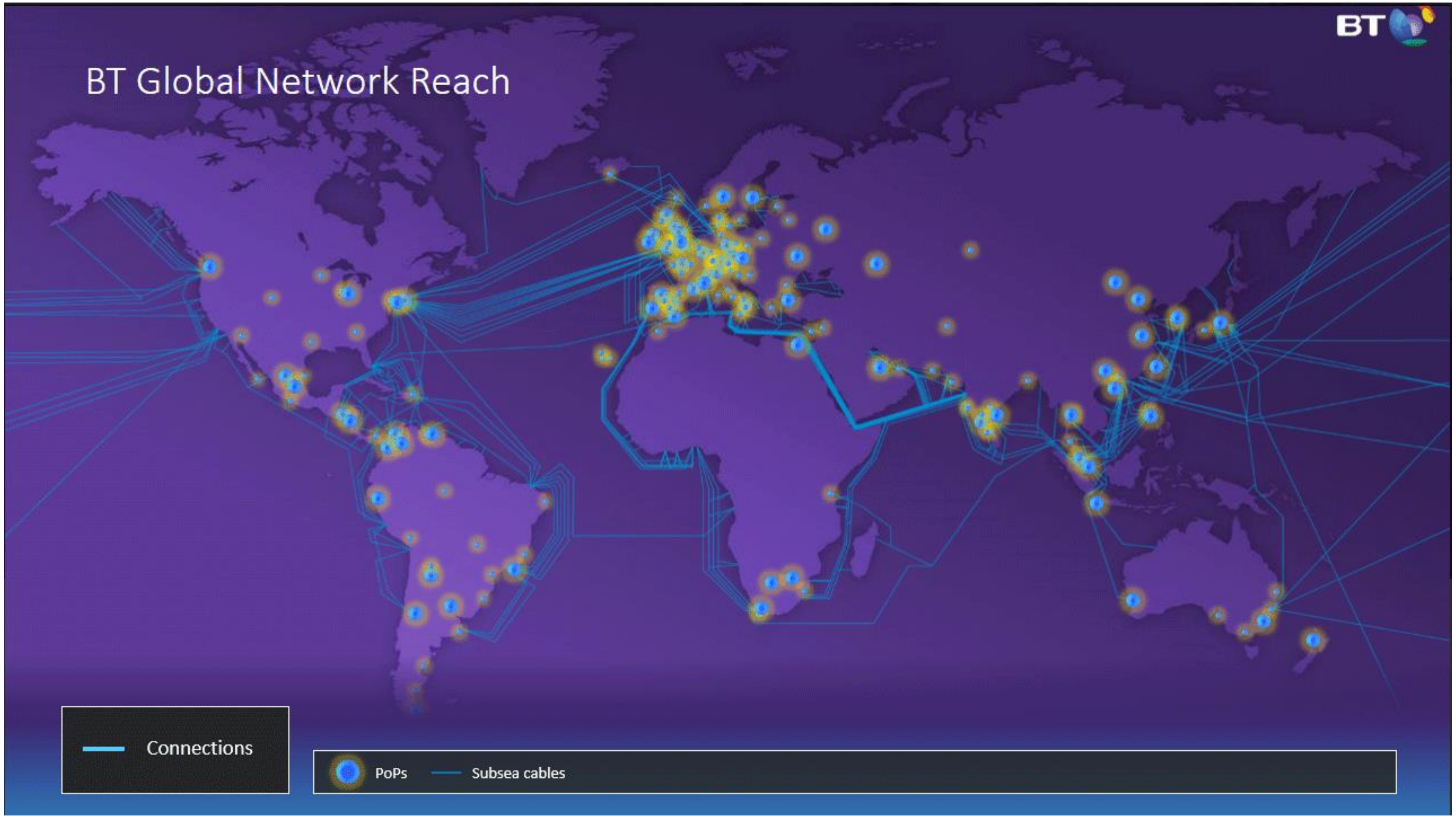
Transit providers, a different business case

1. Verizon: Focus on private-IP/ OTN interfaces with special conditions such as encryption or cloud products.
2. Wholesale transit providers (like Level3): Sell large volumes of data traffic with low margins. According to Mr. Booi this business model is not very profitable.
    a. In the past Level 3 has bought submarine communication cables for a low price. They hoped to sell data for a very competitive price. Level 3 and GlobalCrossing also constructed a trans-Atlantic cable by itself. GlobalCrossing went bankrupted because of this investment.
    b. Other wholesale transit providers such as the former 'Tyco Global Network' (TGN) had 4 billion dollar invested in new submarine communication cables. They were sold later for only 130 million dollar to TataCommunications. According to Mr. Booi even TataCommunications hardly makes money on that cable.
3. Google, Facebook, Microsoft and Amazon have a different earnings model, which is not directly connected with the submarine communication cable industry. However lately these companies started to started to offer cloud services and applications on own networks. This lead to investments in submarine communication cables. First they leased dark fibre pairs on existing cables. In the last years they invested directly in fibre pairs of new submarine communication cables.

Future considerations

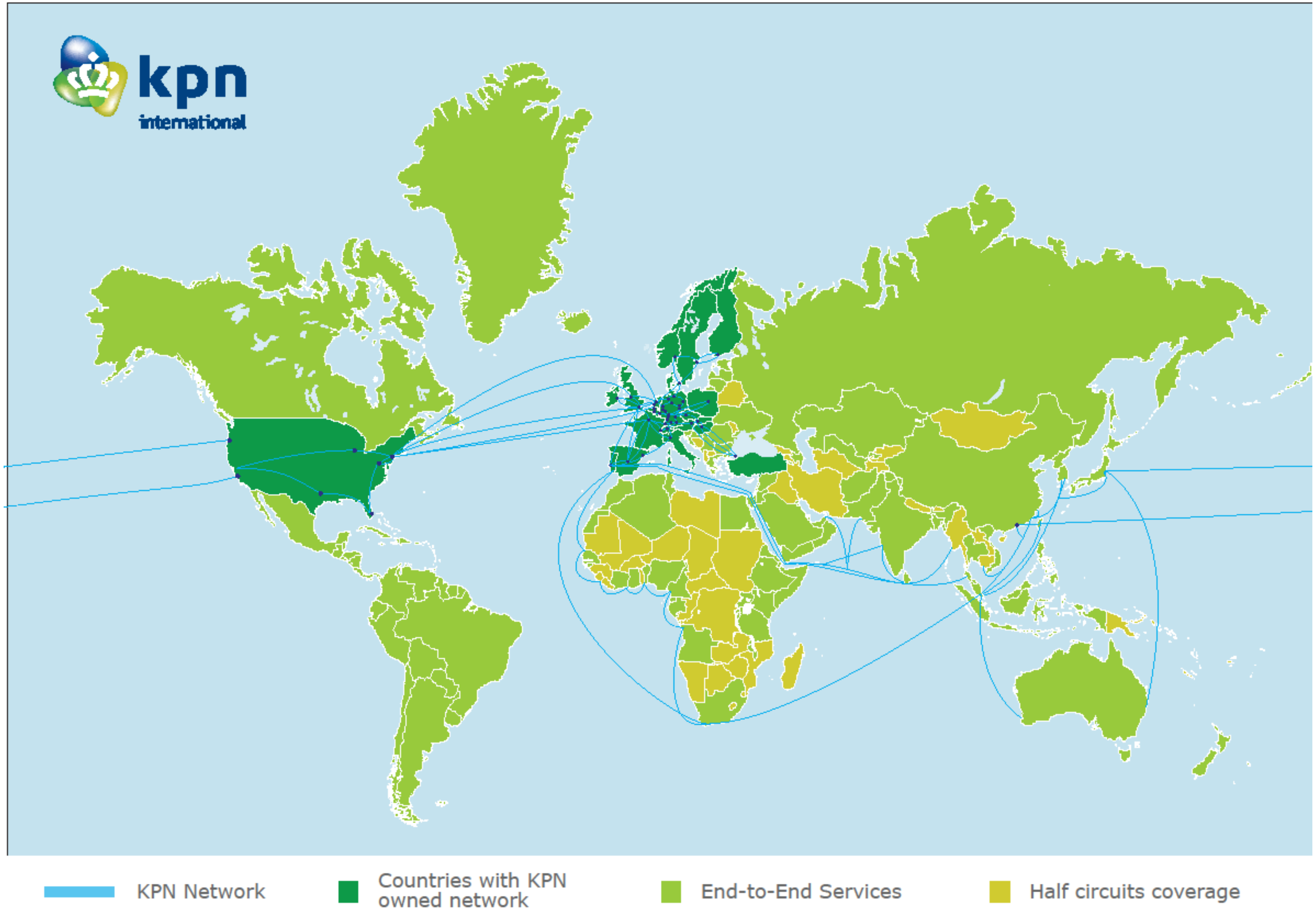
- In the end of the nineties there were a lot of investments in submarine capacity between the USA and Europe. In the years 2001/2002 the market crashed and it turned out there was an abundance of data capacity available. Up to this day there are very competitive prices and unused capacity between Europe and the USA. Only consortium projects like TAT14 turned out to be financial viable because of the spread of risk. A lot of 'private' cable owners went bankrupt.
- Nowadays a lot of cables are constructed towards Asia through the Pacific Ocean. Mr. Booi thinks that this will lead to another bubble. Trends like the regionalization of data through content delivery networks make that these investments are not necessary. 'They are overconfident and invest to much'

Appendix P – BT Global Network Reach

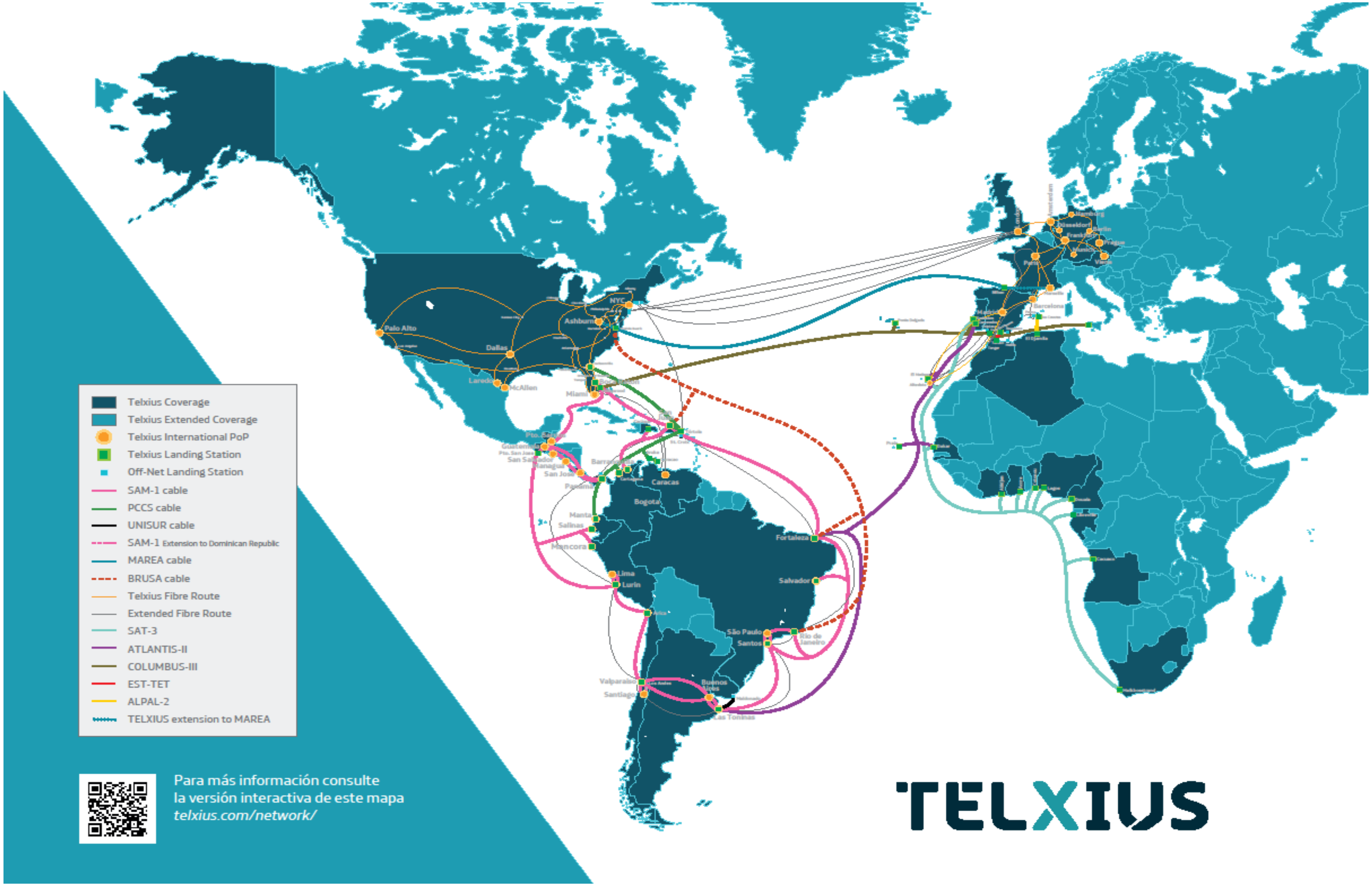


Source: http://www.btfed.com/wp-content/uploads/1-PoPs.png

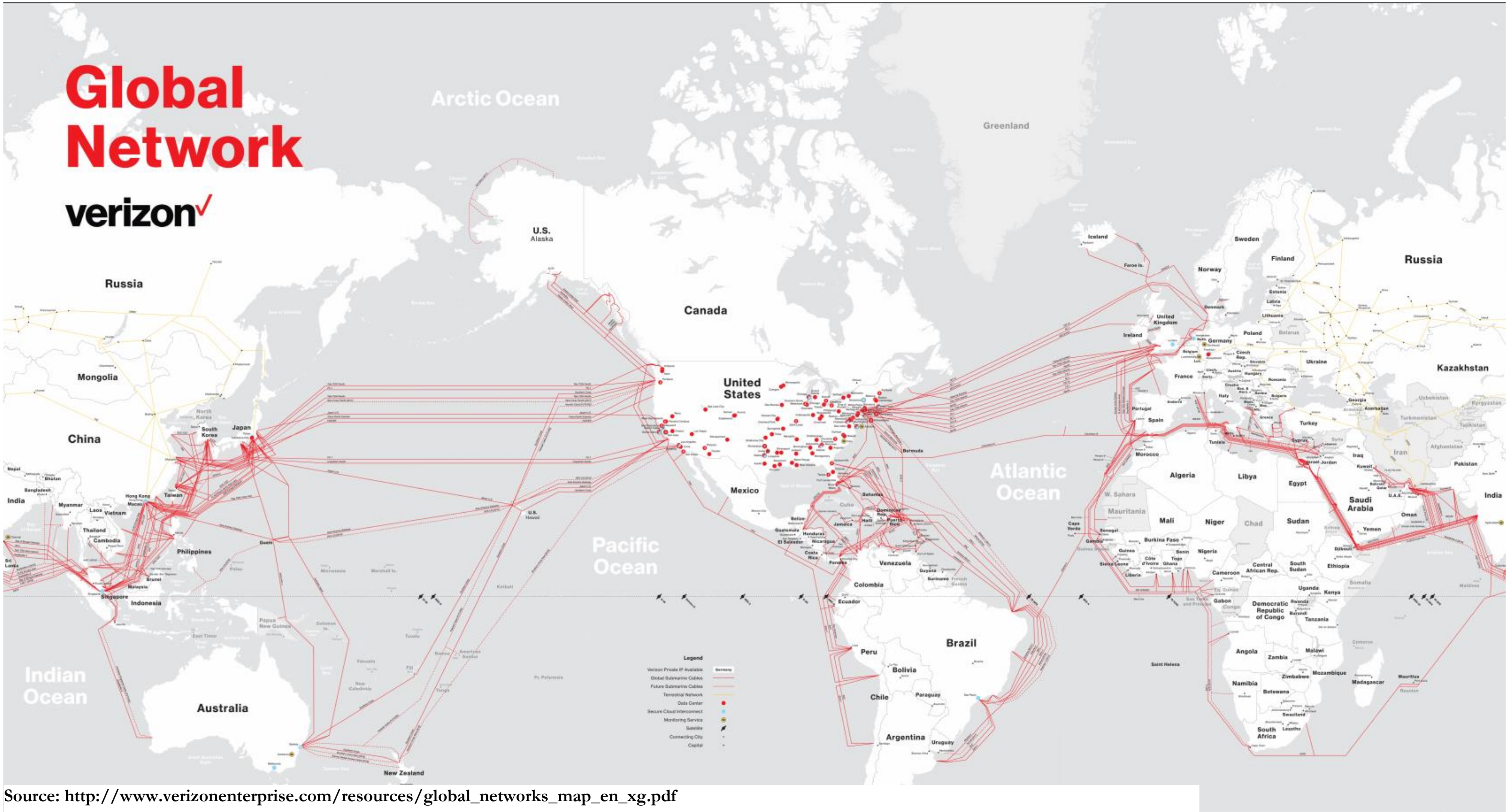
Appendix Q – KPN Global Network Reach


kpn
international
KPN Network
Countries with KPN owned network
End-to-End Services
Half circuits coverage

Appendix R – Telefónica/Telxius Global Network Reach



Appendix S – Verizon Global Network Reach



Source: http://www.verizonenterprise.com/resources/global_networks_map_en_xg.pdf