Economic Impact of Submarine Cable Disruptions

APEC Policy Support Unit
December 2012

Advancing Free Trade for Asia-Pacific Prosperity

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APEC#213-SE-01.2
Published February 2013

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EXECUTIVE SUMMARY

The present study and the economic impact model were prepared for the Policy Support Unit of the Asian-Pacific Economic Cooperation (APEC). They serve to fulfil the goals of the **APEC Supply Chain Connectivity Framework Action Plan (SCFAP),** resolved by the APEC member economies, which contains under its **Chokepoint 7** the protection of submarine cables. The objective is to enhance the security and quality of cross-border communications.

The amount of data and information generated, sent and received through the global submarine telecommunications cable network in recent years has experienced unmatched growth and exceeded any kind of information transmission previously known by far. Deployed international bandwidth increased at a compound annual rate of 57 percent between 2007 and 2011. The situation is no different in the Asia-Pacific region.

Submarine cables carry over 97% of intercontinental data traffic as they provide a more efficient means of transmitting telecommunications than satellites. Two reasons account for the superiority of submarine cables: They are the only technology that can transmit large amounts of information across bodies of water with low latencies (delays), and they do so at low costs.

It is important for all APEC member economies to recognize the fact that modern economies and societies are very much dependent on uninterrupted global data connectivity. Member economies should be aware of the importance of submarine cables and the risk to trade in goods and services, international financial markets, social welfare, political stability, and domestic security posed by submarine cable disruptions.

Despite being examples of advanced technology, submarine cables are susceptible to damage. Cable systems may be disrupted for a number of reasons, each of which has a different profile in terms of the likelihood that their occurrence could damage the overall network performance of an economy. The hazards to submarine cable-bound communication can be categorized into three groups: natural hazards to the cables themselves, man-made hazards to the cables themselves, and hazards to the remaining infrastructure, especially landing stations and IT network management systems. Insufficient availability of repair vessels is a further hazard.

Three especially vulnerable choke points that require special attention were identified: the Strait of Malacca between Malaysia, Singapore and Indonesia; the Strait of Luzon between Chinese Taipei and the Philippines; and the South China Sea.

Connectivity, basic reliability, and redundancy are sufficiently well provided for by the market. The Economic Model, which was prepared for this study in a spreadsheet format, shows that single cable failures do not lead to disruptions of data connectivity anywhere. However, considering the importance of submarine cable systems for the economic and social wellbeing of member economies and the potential consequences of certain disruption scenarios, especially for the so-called choke points (see Economic Model and Chapter 3), it is recommended that member economies devote more attention to the protection of submarine cables and the mitigation of disruptions through partnership with one another and the submarine cable industry.

The basic approach should be to build up capacities to monitor the situation closely, obtain information about the status of the cable network, and to prevent or halt harmful developments as quickly as possible. Basic protection measures should be taken to avoid common, likely hazards on the one hand and less likely, but particularly destructive ones on the other hand. A legal environment should be created that supports the cable operators in their efforts to protect the cables, to mitigate the impacts of cable disruptions, and to create the needed geographic diversity of submarine cables, which is the most effective long term measure to prevent disruptions in data connectivity.

In addition, member economies can and should enact meaningful and modern domestic law to deal with cable faults caused wilfully or through culpable negligence by third parties. They should enact and enforce effective criminal law and provide for access to civil remedies in court, which will deter harmful conduct and allow damages to be recovered from those responsible for disruption.

Due to the limited area of sovereign legal application and enforcement it is difficult for single member economies to establish rules, standards and measures concerning the protection of submarine cables and impact mitigation. Submarine cables are, by nature, trans-border facilities, which have landing points in multiple jurisdictions and run in large parts under international waters (‘High Seas’). International cooperation among member economies and with the cable operators provides the best means of mitigating this challenge.

UNCLOS plays an important role in efforts to protect submarine cables. It is recommended that member economies which are not already State Parties, become State Parties to UNCLOS. This would allow these member economies to enjoy the benefits of UNCLOS’ rights and freedoms while enabling its relevant provisions to become equally binding for all member economies. Member economies should aim at furthering cooperation using this international instrument and thus increase cable protection and mitigation measures through a common, international approach.

While cable operators tend to apply sophisticated technical standards for the deployment of cables (e.g. cable armouring and burying), these measures are voluntary and therefore not necessarily at the same level everywhere. Member economies and cable operators should cooperate in agreeing to common high standards.

Two different questionnaires conducted within APEC in 2009 and in 2012 showed a low general level of awareness concerning submarine cable network protection and maintenance. Australia and Hong Kong, China are two exceptions which could serve as role models.

The main lessons learned about necessary improvements are:

1. Only a few member economies have implemented even a minimum set of protection measures to date. In the long run all member economies should reach the position of adopting minimum cable protection measures in line with the recommendations in Chapter 5. Exemplary economies have adopted a divergent set of measures, stressing some issues but neglecting others, rather than aligning regionally and within APEC to take the trans-border nature of submarine cable systems into consideration.

2. A unified and coherent approach is necessary to create a common framework on submarine cable protection and mitigation which is also commonly enforced and regularly modified to ensure that it remains preventative, collaborative, and combines protective and impact mitigation measures. It is however important that member economies avoid concentrating purely on protection measures regarding the cables.

3. Member economies should take a comprehensive view including advanced mitigation measures and protection measures for other crucial parts of the network such as repair vessels, landing stations and IT systems.

Member economies need to address the difficult trade-off of determining how many resources should be applied to prevent accidents causing cable disruptions which are of unknown likelihood and magnitude. Policymakers face conditions of considerable uncertainty and fiscal constraint. The findings of this study and the economic impact model should help to support decision making here.

The Economic Model, which was prepared for this study, shows the probability of substantial economic losses arising from cable disruption and reflects the increased likelihood of severe disruptions in some regions. An overall recommendation for member economies is therefore to sharpen their focus on the issue of submarine cable protection and risk mitigation. A ‘wait and see’ approach is possibly too risky as too much is at stake.

Given the global nature of this infrastructure, where submarine cables often transit through and terminate in numerous economies, international engagement and cooperation is important. Increased engagement within APEC concerning submarine cable protection and resilience is encouraged to promote greater awareness, cooperation, and collaboration among member economies.

However, it should be noted that the protection and resilience of submarine cables cannot be achieved by member economies or the private sector alone. A strong and effective business-government partnership approach is required and should form the basis of any initiative taken by member economies.

The cable operators generally provide for a sufficiently redundant and geographically diverse deployment of submarine cables and basic protection measures. Overly strong intervention could even hamper investments in additional and better cables, which would be dangerous as a diverse cable network is the best measure to prevent traffic distortions.

Through a collaborative partnership with submarine cable owners and operators, member economies will be able to tap into the expertise and knowledge of industry to gain insights into issues, threats and hazards impacting submarine cable protection, while at the same time being able to influence and shape the thinking and actions of the industry.

Member economies should get to know the status of their respective cable systems, obtain a comprehensive overview, monitor the situation, and take individual measures where necessary in accordance with the measures recommended throughout this study and in Chapter 5. For this to be achieved, it is necessary to strengthen human capacity, establish streamlined and efficient dedicated working bodies; and enact and enforce modern, meaningful legislation.

Here member economies should consider engaging with and becoming a member of the International Cable Protection Committee (ICPC). The ICPC consists of over 120 member organisations representing all parts of the industry from across the globe, including the Asia-Pacific region, and has the primary goal of promoting the safeguarding of submarine cables against man-made and natural hazards. Membership of the ICPC is also open to governments, making it an important multilateral and international forum for industry and governments to discuss issues relating to submarine cable protection and resilience. Within the region the governments of Australia and Singapore are currently members. Specified protection and mitigation measures are suggested in more detail in Chapter 5.

1. DEVELOPMENT OF SUBMARINE CABLE SYSTEMS IN THE APEC REGION

INCREASING NEED FOR INTERNATIONAL BANDWIDTH

The world we live in is changing rapidly. The pace of inventing, developing and deploying new technologies has accelerated significantly. In ever shorter periods of time, new gadgets - especially in the field of information and communications technology (ICT) - are being invented and introduced. The pace of development, if compared to the millennia of human history before, was already fast during the first eight decades of the twentieth century, but the invention of the internet and its broad availability during the 1990s has had an almost revolutionary effect on the already high speed of innovation.

The amount of data and information generated, sent and received worldwide using this global network has been experiencing unmatched growth since then and has far exceeded any kind of information transmission known before. It is mainly the internet's demand that has driven the sharp increase in globally deployed bandwidth - accounting for 81.9% of its usage in 2011, with private networks consuming virtually all remaining bandwidth (17.87%). Traditional switched voice bandwidth can almost be neglected – it accounts for just 150 Gbps or 0.22% in 2011.

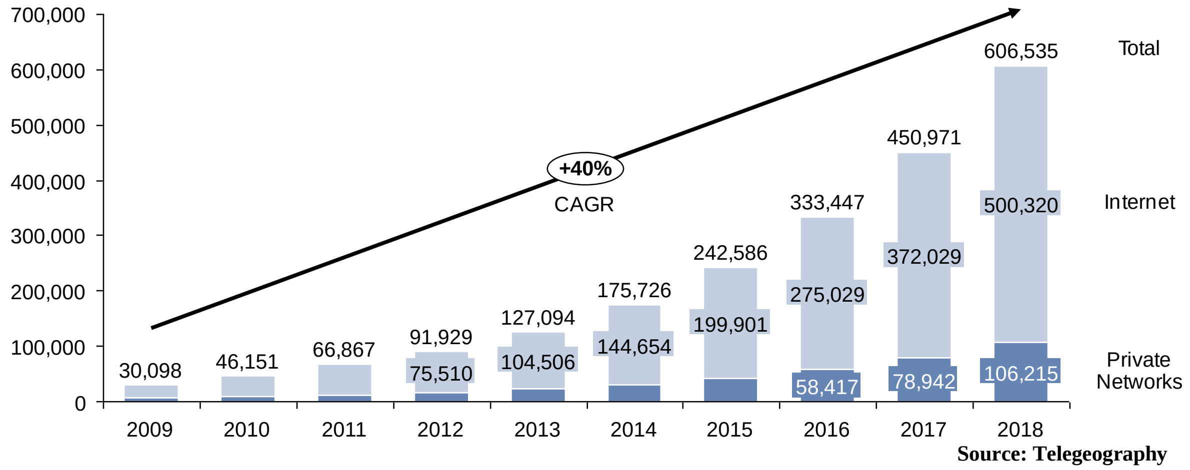
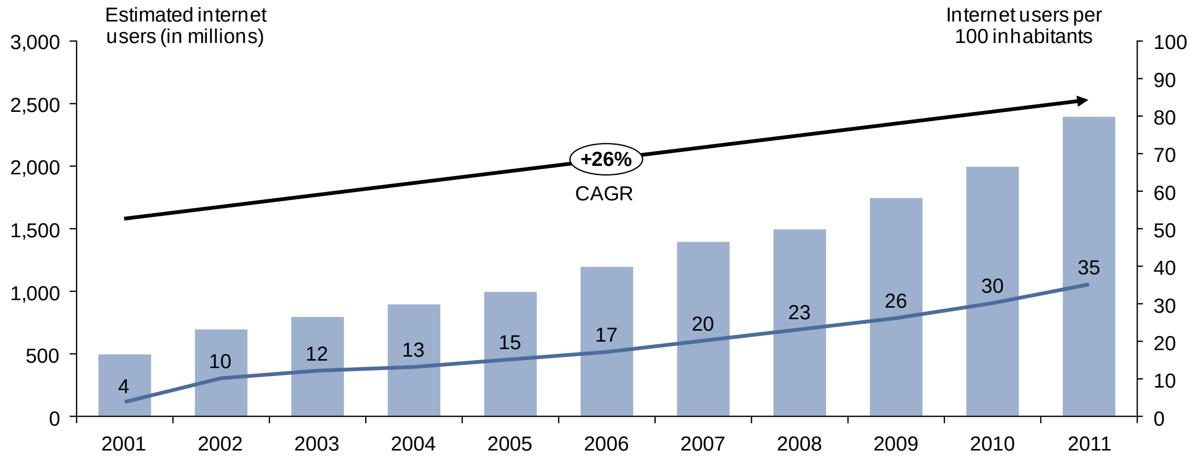


Figure 1: Global total used bandwidth (in Gbps)

Deployed international bandwidth increased at a compound annual growth rate of 57 percent between 2007 and 2011[1]. It reached 67 Tbps in 2011, which was six times the bandwidth in use in 2007 (11.1 Tbps). And this development is expected to continue at almost unimpeded speed: the current forecast for bandwidth deployment shows a staggering compound annual growth rate of 40% from 2009 to 2018, leading to an amount of more than 600 Tbps in 2018. At this pace, the amount of international bandwidth in the world will double approximately every two years.

[1] Global Bandwidth Research Service, Telegeography, 2012

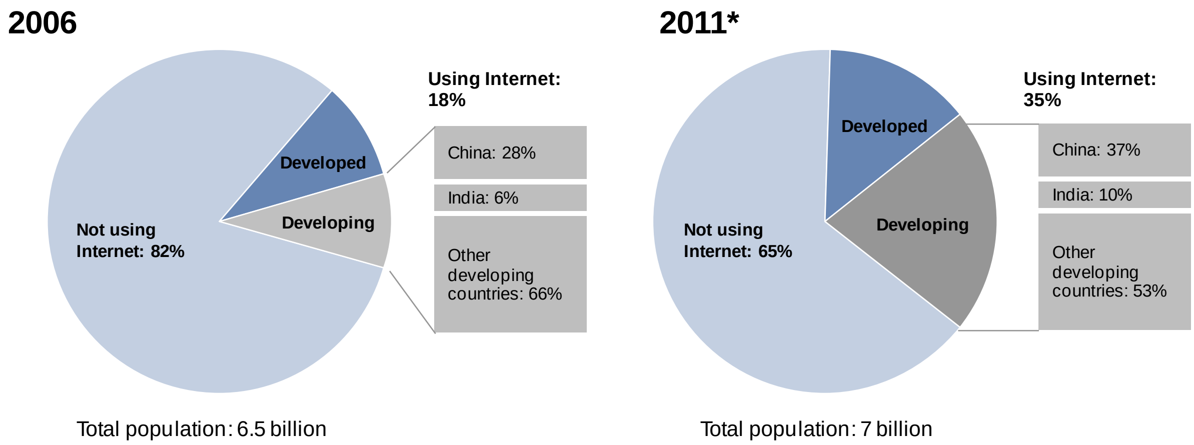
Today more than a third of the world's population is using the internet, i.e. a staggering 2.45 billion people.



Source: ITU

Figure 2: Global number of internet users total and per 100 inhabitants

In contrast to the early years of its development, the internet is no longer just a privilege for the inhabitants of the developed economies, but instead is a worldwide phenomenon. Especially during the last five years, most of the increase in internet users has come from developing economies. During this period, the developing economies' share in the world's total number of internet users has increased from 44% to 62% (2006 to 2011)[2]. Internet users in China presently represent almost 25% of the world's total and 37% of the developing economies' internet users. 45 % of all users are below the age of 25, a whole new generation of so-called "Digi-Natives"[3]. This rapidly increasing number of internet users around the world is a major growth factor for global data traffic.

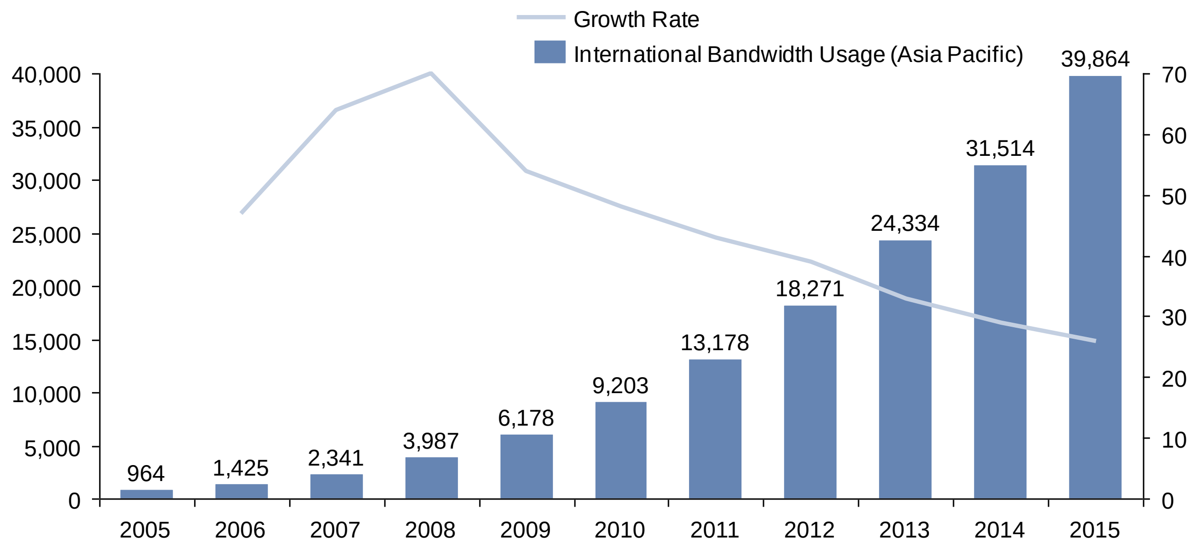


Source: ITU

Figure 3: Internet Usage

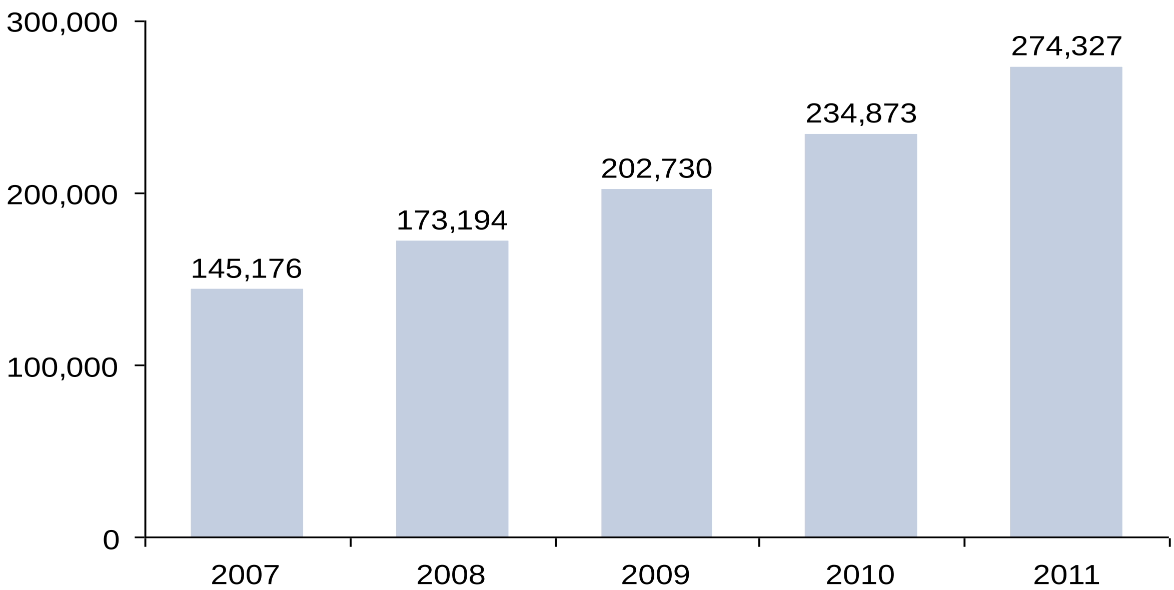
[2] The World in 2011: ICT Facts and Figures, ITU, 2011, page 1
[3] The World in 2011: ICT Facts and Figures, ITU, 2011, page 1

The situation is no different in the Asia-Pacific region: During the period 2005 - 2011, international data traffic in the top 14 Asia-Pacific markets increased by a breathtaking 1267%, which is equivalent to a Compound Annual Growth Rate (CAGR) of 54%. Forecasts indicate that this growth in bandwidth usage will continue. International bandwidth usage is expected to have a CAGR of 31.75% from 13,178 Gbps at the end of 2011 to 39,864 Gbps at the end of 2015.[4]



Source: Frost & Sullivan

Figure 4: International bandwidth usage of top 14 markets in Asia-Pacific region[5]



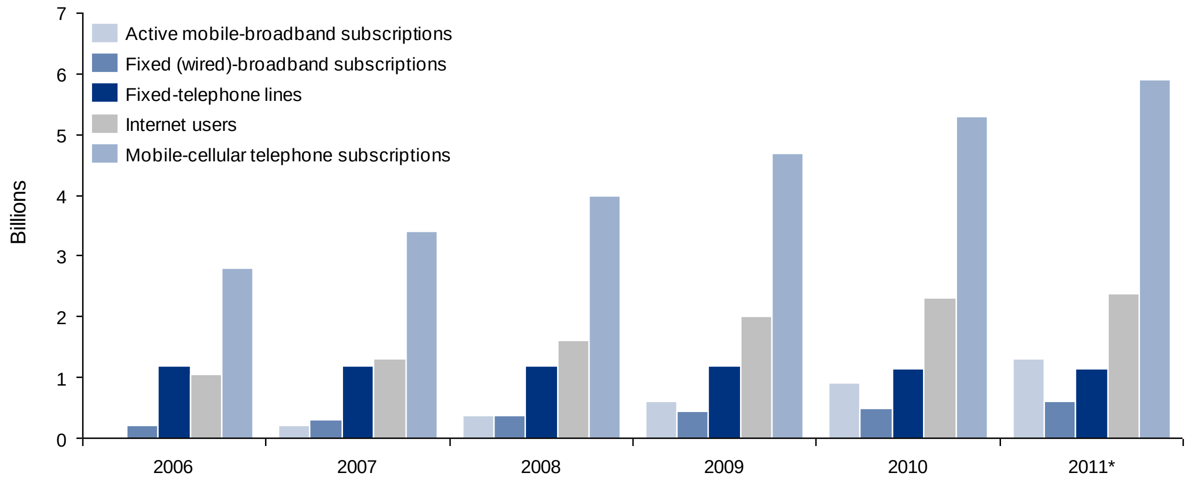
Source: Ovum

Figure 5: Broadband connections in Asia

[4] Submarine Cable Networks Outlook, Frost & Sullivan, 2009
[5] Submarine Cable Networks Outlook, Frost & Sullivan, 2009 - Bandwidth Usage Share of top 14 markets in Asia-Pacific region: Japan (27%), China (24%), Hong Kong (13%), Singapore (8%), Australia / New Zealand (7%), South Korea / Chinese Taipei / Malaysia / Indonesia / Philippines / Thailand / Viet Nam (6%), India (3%)

There are three main factors driving the strong increase in bandwidth demand:

1. One factor driving the number of internet users in the developing world in particular is the **increasing availability of mobile and wireless broadband solutions**. Fixed cable-bound systems, e.g. standard copper telephony connections, which enable technologies like ADSL, are not widely available in developing economies and thus access to traditional telephony and the early internet has not been possible for much of the population, especially in rural regions. Given this lack of fixed infrastructure, the introduction of new mobile telephony standards and wireless broadband technologies drastically changed the situation. Cell phones are now the primary means of connecting to the internet in these economies. For example, in Indonesia there are 2.6 million fixed broadband subscribers but more than 36 million 3G subscribers[6]. The fact that the total number of mobile subscriptions (including 2G) in Indonesia is close to 250 million shows that there is still huge growth potential for mobile internet. The further deployment of wireless broadband technologies such as 3/3.5G, WIMAX, EVDO and LTE can be expected to further accelerate the bandwidth demand from broadband subscribers.



Source: ITU

Figure 6: Worldwide usage of different ICT technologies

With a total of 5.9 billion mobile subscriptions, the global mobile penetration has reached an overall value of 87%, and 79% within the developing world. Half of this number of people, 45% of the world's population, is covered by broadband 3G / UMTS technology, which is giving more and more people the opportunity of fast access to the internet. The number of active mobile-broadband subscriptions has increased to almost 1.2 billion[7]. Overall mobile-broadband subscriptions have grown 45% per annum for the last four years and today there are twice as many mobile-broadband as fixed-broadband subscriptions[8].

[6] Global Bandwidth Research Service, Telegeography, 2012
[7] The World in 2011: ICT Facts and Figures, ITU, 2011, page 4
[8] The World in 2011: ICT Facts and Figures, ITU, 2011, page 2

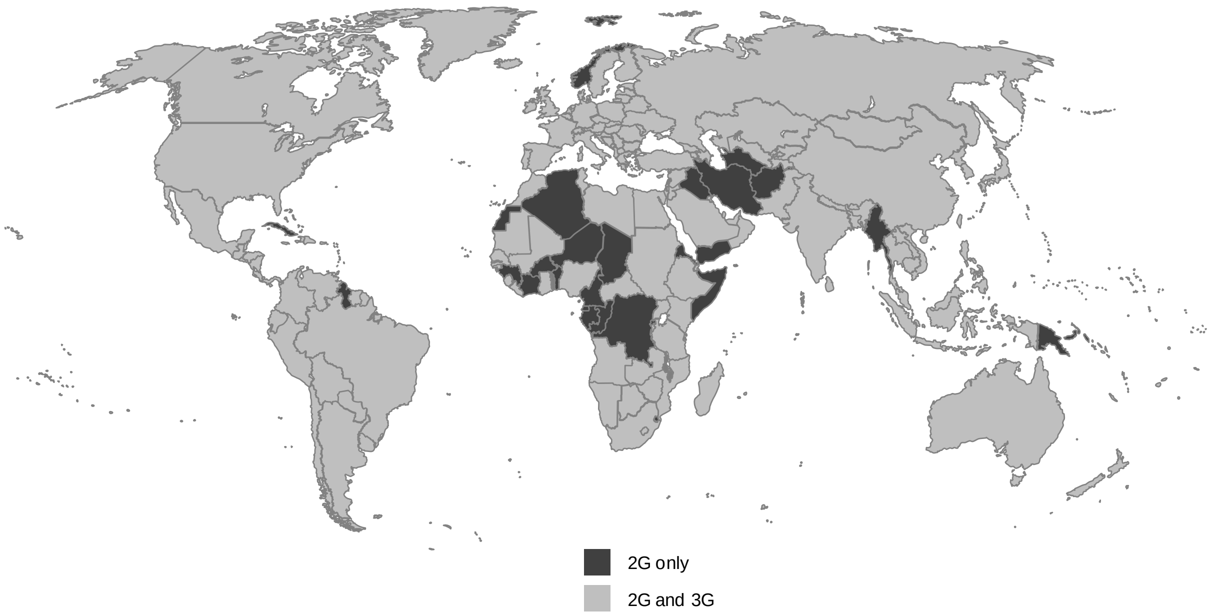


Figure 7: Worldwide coverage of 2G and 3G mobile-cellular coverage

2. The second important factor is the **sharp increase in bandwidth usage per subscriber** in the developed markets. This is especially driven by the proliferation of video sharing via streaming and buffered media, now even being delivered in High Definition, as well as music and file sharing applications especially via peer-to-peer (P2P). New but increasingly important factors are cloud applications, which are creating additional traffic for web based productivity solutions ranging from Software as a Service (SaaS) over Platform as a Service (PaaS) to Infrastructure as a Service (IaaS).

   Video accounted for the largest share of mobile traffic by application with 42 percent. YouTube alone accounted for 24 percent of the world's mobile data traffic and file sharing for 26 percent. VoIP and instant messaging were also big drivers of mobile data usage, with both more than doubling their bandwidth needs in the past year[9].

3. In addition, **the enterprise sector is driving demand for submarine cable capacity with the increasing use of high throughput applications**. Many enterprises are using business process outsourcing (BPO) services to decrease their costs and they are also increasing their adoption of applications such as tele-presence for collaboration between different geographic locations[10].

INCREASING DEPLOYMENT OF SUBMARINE CABLE SYSTEMS

Importance of submarine cable systems

Communication over long distances, especially in the form of data, has become the life-blood of the modern world. And fibre optic submarine cables serve as the arteries. Without

[9] Global Bandwidth Research Service, Telegeography, 2012
[10] Submarine Cable Networks Outlook, Frost & Sullivan, 2009

submarine cable systems, global telecommunications, including the internet, as we know it, with its sophistication, speed and resilience, would be impossible. **Modern submarine cable systems carry over 97% of intercontinental data traffic**[11]. Just 20 years ago the internet and mobile telephony were almost unknown, but today a world without them is hard to imagine - and submarine cables made this development possible.

Communication using submarine cables dates back over 150 years to when the first telegraph cable was installed between England and France. From the mid-1960s satellites were used to route telecommunications, for submarine cables were considered slow and less reliable. It was only in 1988 that developments in high-speed and high-capacity digital transmission over fibre-optic submarine cable technology first enabled the reliable and high quality transmission of vast quantities of information across oceans. This coincided with the introduction of the internet in 1991. The two technologies supported each other and revolutionized communications.

This importance of submarine cables was accompanied by massive investments and capacity building which will be described below in more detail. But this was rather the result than the cause.

The real drivers which led to the importance of submarine cables are:

1. The most important driver is the **surging demand for bandwidth as depicted above**. This correlates with a demand for infrastructure to physically carry the data traffic produced. At the access, aggregation and backbone levels these IP-packages are typically transported in landlocked cables made of copper or nowadays of fibre (even to the access levels such as FTTH, FTTC) or via mobile radio access technology. But as soon as the traffic has to leave the territory of a certain economy or arrives from such a source abroad, waterways, seas and oceans have to be crossed. This includes nearly all internet related data traffic as most of the sources accessed are located on servers in the United States, or to a smaller extent in European economies or somewhere else across the world. It is impossible to use the internet on the basis of a single economy.

2. **Rising IP transit and international bandwidth revenues** make it increasingly attractive for investors and new operators to enter the global transmission business, invest in new cables and capacities, and gain a share of this rapidly growing industry.

3. **Growing demand for physical redundancy**, e.g. following the December 2006 earthquake in Chinese Taipei, requires additional routes and cables even when this is not entirely necessary to satisfy current bandwidth demands.

4. **Domestic telecommunication companies are integrating increasingly with** cable networks to position themselves to meet long-term demand growth driven by broadband uptake and to create new revenue streams.

[11] Submarine Fiber Optic Communications, HCom Ltd., 2011

Submarine cables are the superior transmission medium

Theoretically, the transport across waterways is possible using two different technologies: submarine fibre optical cable systems or satellite transmissions. When comparing both technologies it becomes clear that four main factors make submarine cables the preferred method of transportation:

1. The first factor is the **speed of the signal, i.e. small latency**. Latency is the amount of time by which the signal is delayed until it reaches its recipient. A signal relayed by a geostationary satellite must travel about 72,000 km up to the satellite and back to earth, so there is a noticeable time delay (at least one quarter of a second) in most conversations sent by satellite. Between the US and Japan an IP-package sent via satellite has an average delay of 650 msec, whereas the delay on a fibre submarine cable is just 120 msec. Even differences on this level impose a noticeable decrease in quality and are visible for normal internet users browsing the web. In addition, there are numerous modern applications which strive for the highest possible delivery speed for information. The most powerful example is the so called "**high-frequency trading".** This is automated financial trading, where computers buy and sell stocks and other financial instruments with no human input. Despite calls for more regulation, these networks are evolving quickly. Already, more than 60 percent of U.S. financial trading and a third of European trading filters through a high-frequency trading platform[12]. Brokers and bankers using this kind of trading scheme are willing to invest significant amounts of money to maximise the speed of their data connection as every single millisecond counts to make them faster than their competitors.

2. The second factor is **bandwidth limitation**. The average bandwidth of modern submarine cable systems is significantly higher than that of satellites. In addition, depending on their design, submarine fibre systems, can often be massively upgraded and bandwidth increased even after their initial rollout. This is not possible with satellite equipment once it has left earth.

3. The third and probably most important factor is that **prices for data transmission** via submarine cable are far lower than for those via satellite. The initial costs for building a satellite and bringing it into orbit might not be so different to the costs for planning, producing and deploying submarine cables: both cost hundreds of millions of dollars. But if the different bandwidths are taken into account, it becomes very clear that the cost per Gbit transported is considerably higher for satellites than for submarine cables: The average unit cost per Mb/s capacity based on 2008 prices were USD 740,000 for satellite transmission but only USD 14,500 for submarine cable transmission.

   A further factor increasing the cost per Gbit for satellite is the different average lifetime expectation of submarine cables and satellites and the corresponding allocation of installation costs per annum. Whereas the expected operating life for satellites is typically about 10 years, submarine cables can be expected to last twice as long.

4. A fourth factor is that overall **submarine cable networks are more reliable** than satellites. Satellites are safe from the man-made hazards which often damage single submarine cables, and from natural disasters that endanger whole regional cable clusters.

[12] Business at the speed of light - what is a millisecond worth, Tony Greenberg, 2012

The main distortion for satellite systems are physical phenomena such as sunspot solar activities (sun winds), radio frequency interferences, the refractive index, and beam bending. They are not rare, but they typically only cause temporary distortion and no permanent damage to the system.

It is rather the lack of redundancy that limits the reliability of satellite transmission systems. If a satellite fails or its signal is just temporarily distorted by the factors stated above, there is typically no alternative satellite available to maintain uninterrupted transmission for that time, as there are simply too few of them up in the sky. In contrast submarine cables are nowadays plentiful: while permanent damage to particular systems may indeed cause reductions in bandwidth and speed, a total blackout is very rare nowadays.

These advantages of submarine cable systems are overwhelming: The share of traffic between satellite and submarine cables was around 50/50 in 1995. Today submarine cables carry more than 97% of the worldwide data traffic, leaving satellites with just a 3% share. Satellites may still have their uses: as emergency redundancy in disaster-prone areas; to provide wide coverage for mobile subscribers; and to link isolated regions and small islands. But these use cases are only to be found where there is no better alternative via cables, are bought for high prices and become less common as more regions are connected to the global cable network.

A comparison between submarine cables and landlocked cable systems for data communication shows that they are technically equally capable but the landlocked systems face difficulties for global connections, especially routing through numerous sovereign territories. Anyway, APEC member economies are mostly coastal or even islands. At some point any network in the APEC region has to cross an ocean. Hence, land cables cannot completely substitute submarine cables for global connections.

In summary, submarine cables are the only technology that can transmit large bandwidths across bodies of water with low latencies (delays), better reliability and at low costs.

ECONOMIC, SOCIAL AND DOMESTIC SECURITY IMPORTANCE OF SUBMARINE CABLE SYSTEMS

The submarine cable network is designed to be resilient. However, faults can disrupt services and activities which we take for granted nowadays.

Economic dependency

Concerning the **economy**, we live in a world where ICT is no longer just an industry in itself or just a support for other businesses. It has become an integral success factor and an irreplaceable part of the production scheme of almost every industry. **Most of the business activities of international companies (no matter from which industry) rely heavily on being interconnected internally and externally via the worldwide web. Submarine cable systems are the vital backbone of this network**. Singapore's Permanent Representative to the UN, Ambassador Vanu Gopala Menon, noted recently that “these unseen and unsung cables are the true skeleton and nerve of our world, linking our economies together in a fibre-optic web”[13].

By way of example, the **direct contribution of the internet to the Australian economy** was worth approximately Au$50 billion in 2010[14]:

- This is equivalent to 3.6% of Australia’s Gross Domestic Product (GDP)
- The value of the web for the economy is growing by 7% per annum (twice as fast as that forecasted for the rest of the economy)
- In addition, the internet contributed AU $27 billion in productivity boosts for businesses and government in 2010 and AU $53 billion in benefits to households in the form of added convenience
- The direct contribution of the internet to the Australian economy is set to increase by Au$20 billion over the next five years, from Au$50 billion to roughly Au$70 billion.

Some industries, especially the financial sector, could scarcely exist nowadays without highly sophisticated IT systems and a continuous worldwide data stream. The extreme example of high-speed trading was already explained above. For the global financial flows submarine cable systems are exceptionally important[15]:

- At a recent cable seminar, a U.S. Federal Reserve representative stated that cables globally carry an excess of US$10 trillion a day in transactions.
- The Society for Worldwide Interbank Financial Telecommunication (SWIFT) network uses undersea fibre-optic communications cables to transmit financial data to more than 8,300 member financial institutions in 195 economies. In 2011, SWIFT’s network handled nearly 15 million messages daily.
- The CLS Bank (Continuous Linked Settlement) operates the largest multi-currency cash settlement system in the world, trading over 1 million transactions and over US$4.7 trillion a day via undersea cables.
- The U.S. Clearing House Interbank Payment System processes over US$1 trillion a day in transactions with more than 22 economies.

Figures concerning the **dependency of the Australian finance sector on submarine cables** indicate the following[16]:

- On average, non-cash payments worth around Au$220 billion are made each business day
- This is an equivalent to about 20 per cent of GDP
- More than 75 per cent of this value is accounted for by a small number of high-value payments
- Most of the value of these payments relates to the settlement of foreign exchange and securities markets transactions.
- Even from a retail customer’s perspective, such daily activities as banking, airline bookings and shopping, are based more and more on ICT dependent solutions.

[13] Guard the submarine cables that link us all, Tara Davenport, 2010
[14] The Connected Continent – How the internet is transforming Australia’s economy, Deloitte Access Economics, 2011
[15] New threats, old technology, Michael Sechrist, 2012
[16] Figures of the Reserve Bank of Australia, Reserve Bank of Australia, 2010

General perspectives and outlook

It is not only the economy that is increasingly dependent on the uninterrupted worldwide data stream, almost all communication and information sharing is nowadays based on this network. Just 20 years after the introduction of the internet, ICT based solutions are almost indispensible for **education, science and research, for health institutions, for politics, administration, security and defence and our daily social, personal, and cultural interactions.**

In addition, almost **all current important innovation is based on ICT** and derives its advantages from an increasing degree of real-time information sharing, storage and processing: e.g. smart grids and smart metering in the energy sector, eHealth solutions in the health sector, and intelligent fleet management and integrated online applications in the automotive and transportation sector. The so-called "Internet of Things" and "Autonomous Systems" are evolving where everything is connected to everything and these may continuously communicate with each other without any human input using automated Machine-to-Machine-Communication (M2M).

It is important for all member economies to be aware of this increasing importance of ICT. Their awareness of the related importance of submarine cables and the risk to trade in goods and services, international financial markets, social welfare, political stability and domestic security posed by submarine cable disruptions must be raised – and their level of focus on the topic adapted accordingly.

ACTIVE SUBMARINE CABLE SYSTEMS IN THE APEC REGION

As a consequence of ICT developments, existing submarine cable systems have been upgraded significantly during recent years and new ones have been deployed. The current design of the fibre optical submarine cable systems in the APEC region is the result of more than a decade of ongoing development and construction.

The largest part of the Asia Pacific submarine data traffic is carried on the Trans-Pacific route. In 2008 the capacity of the Trans-Pacific systems grew by 4 Tbps to reach 7.3 Tbps. It should be noted that only about 30% of this available maximum potential capacity are lit, i.e. actually used for data transfer, on an overall, cumulative basis[17].

Submarine cables are always deployed with excess capacity to accommodate significant increases in bandwidth demand. Multiple fibre pairs are deployed and additional fibres are lit as the demand for bandwidth arises. The total potential or the equipped capacity of a submarine cable is given by the sum of its lit and unlit capacity. Lit capacity is the capacity of the fibres that are activated and are being used for data transmission. Unlit capacity is determined by the potential of the dark fibres that are currently not used for transmission.
Hence, there is extensive redundancy in the overall network – needed to reflect the long term planning and extension cycles of submarine cables – although the usage ratio may be considerably different for each single cable and much higher for certain ones.

The long and intensive deployment activity has yielded a much denser and more comprehensive network in the Asia-Pacific region: **As of June 2012, 37 submarine cable**

[17] Submarine Cable Networks Outlook, Frost & Sullivan, 2009, page 9

systems are in use, serving more than one APEC member economy. They are all less than 15 years old (1998 and more recent) and cover the Asia-Pacific region[18].

Submarine cables are notorious for their **long planning and production cycle** of around two to three years. This does not allow for rapid reactions to market changes - neither in terms of quickly adding new capacity when demand is growing faster than expected, nor too much in terms of aborting cable projects where the planning, construction and especially financing process has already progressed considerably. If new capacity is added, this tends to happen in bigger waves, whereas missing market incentives lead to visible declines in cable deployment activities. This results in cyclic cable deployment development.

This cyclic investment behaviour is well reflected in historic data for those cables that were planned before and around the year 2000, when the so-called “dotcom bubble” was at its climax and economic expectations and projections connected to the internet reached levels of hysteria. Financial speculators invested heavily in building and deploying cables to accommodate the predicted internet boom. During the period 1999 - 2002 14 new cables were made ready for service in the APEC region. According to available data on 13 of these cables, they added a total maximum bandwidth of 140,000 Gbps. The fact that even after the burst of the bubble in the first half of 2000 another eight cables were deployed by 2002, is evidence of the above stated relative inflexibility of the submarine cable planning cycles. Once the boom had attracted the investors to plan the cable, the deployment was executed irrespective of demand developments.

After the burst of the dotcom bubble there was however a delayed decrease in new cable deployments and the created overcapacities slowed down further new deployments. But the decrease was only medium-term as demand caught up on the busy routes. From 2003 to 2007 only five new cables were made ready for service and, except for SeaMeWE-4 connecting Asia and Europe, these cables were only minor ones. But the continuing increase in internet usage and data services in the APEC region demanded new bandwidth to be added. In addition, the infrastructure cost went down significantly[19]. So a new planning cycle began and in the year 2008 alone, six new cables started operations, followed by another five in 2009 and two in 2010. Trans-Pacific total lit capacity grew by 120% in 2008 alone[20]. These 13 new cables added an additional bandwidth of several thousand Gbps of current bandwidth and can be upgraded considerably: Improvements in transmission technology have resulted in a much higher potential capacity of these newly deployed cables, which now have ultra-high throughputs close to one or several terabits per second[21]. Following this powerful boost to the region’s capacities, the demand seemed to be met for some time. Only two new cables were added in 2010 and none in 2011. But the next planning cycle has already started and a new wave of cable deployment will soon begin.

Overall, between the years 1998 and 2012 an impressive 37 new cables in scope started operations in the APEC region adding an incredible 218.000 Gbps of bandwidth. The combined length of all these systems in scope is around 445.000 kilometres – more than the distance from the earth to the moon.

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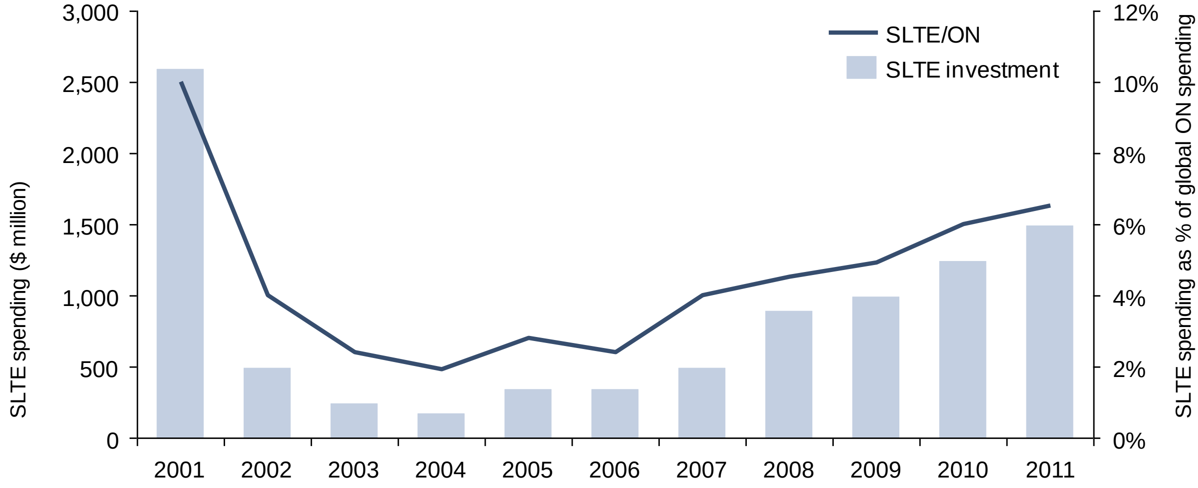
[18] These three criteria define those cables that are in scope for the purpose of this study. If not noted otherwise, all figures hereinafter refer to cables matching these criteria.
[19] Submarine Cable Networks Outlook, Frost & Sullivan, 2009, page 2
[20] Submarine Cables in Asia, Ovum, 2008
[21] Submarine Cable Networks Outlook, Frost & Sullivan, 2009, page 2

The amount of money which was invested is even more impressive: On the basis of the publicized official figures, a staggering US$ 19 billion was spent on their construction.



Source: Ovum, 2008

Figure 8: Comparison of investments in SLTE/ON

SLTE: Submarine line terminating equipment; ON: Global optical networking equipment

Nr.	Cable Name	Abbreviation	RFS Year	Cable Length in KM	Construction cost in USD	Lit Fiber Pairs (Current)	Lit Fiber Pairs (Potential)	Lit Wavelengths per Fiber Pair (Current)	Lit Wavelengths per Fiber Pair (Potential)	Gbps per Wavelength (Current)	Gbps per Wavelength (Potential)	Capacity 2012 (Gbps)	Max Capacity (Gbps)
1	Sea-Me-We-3	Se-Me-We-3	1999	39000	1173000000	2	2	*	*	10	10	400	400
2	APCN-2	-	2001	19000	1060000000	8	8	66	66	10	40	3.840	21.120
3	Australia-Japan Cable (AJC)	AJC	2001	12700	550000000	2	2	16	32	10	40	320	2.560
4	China-U.S Cable Network (CHUS)	CHUS	2000	30476	1400000000	8	8	8	8	2,5	2,5	160	160
5	Pacific Crossing-1 (PC-1)	PC-1	1999	20900	1200000000	8	8	*	40	10	10	2.060	3.200
6	SeaMe WE-4	Se-Me-We-4	2005	20000	500000000	2	2	*	60	10	40	1.620	4.800
7	FLAG Europe-Asia (FEA)	FEA	1997	28000	1600000000	2	3	*	39	40	40	440	4.680
8	Jakabare	-	2009	1330	n.a.	1	2	16	64	10	10	160	1.280
9	EAC-C2C	-	2002	36500	2147000000	*	12	*	*	10	40	2.560	30.550
10	Tata TGN-Intra Asia (TGN-IA)	TGN-IA	2009	6700	250000000	4	4	*	96	10	10	1.900	9.600
11	FLAG North Asia Loop/REACH North Asia Loop	FNAL/RNAL	2001	9504	750000000	8	12	40	62	10	40	2.260	19.800
12	Asia-America Gateway (AAG) Cable System	AAG	2009	20000	560000000	2	2	25	65	10	40	500	5.200
13	Australia-Papua New Guinea-2 (APNG-2)	APNG-2	2006	1800	11000000	*	2	*	*	*	*	n.a.	n.a.
14	Batam Dumai Melaka Cable System (BDMCS)	BDMCS	2009	353	n.a.	1	2	8	64	10	10	80	1.280
15	Batam-Rengit Cable System (BRCS)	BRCS	2007	63	10000000	1	*	1	*	10	*	10	n.a
16	Dumai-Melaka Cable System	DMCS	2005	159	9000000	2	2	1	16	10	10	20	320
17	Hokkaido-Sakhalin Cable System (HSCS)	HSCS	2008	570	50000000	*	*	*	*	10	10	40	640
18	Japan-U.S. Cable Network (JUS)	JUS	2001	22682	1000000000	8	8	32	34	10	40	2.560	4.720
19	Korea-Japan Cable Network (KJCN)	KJCN	2002	500	60000000	2	24	5	24	10	10	160	5.760
20	Matrix Cable System	-	2008	1055	n.a.	2	4	6	64	10	10	170	2.560
21	Moratelindo International Cable System-1 (MIC-1)	MIC-1	2008	70	12000000	1	*	4	*	10	10	40	n.a.
22	Pan American (PAN-AM)	PAN-AM	1999	7050	214000000	2	2	7	7	10	10	140	140
23	Pipe Pacific Cable-1 (PPC-1)	PPC-1	2009	6900	179000000	1	2	20	96	10	10	200	2.560
24	Russia-Japan Cable (RJCN)	RJCN	2008	1800	43000000	2	*	6	*	10	10	60	1.280
25	South America-1 (SAm-1)	SAm-1	2001	25000	1600000000	8	8	*	48	10	40	3.600	15.360
26	South American Crossing (SAC)/Latin American Nautilus (LAN)	SAC/LAN	2000	20000	800000000	8	8	69	256	10	10	1.540	9.940
27	Southern Cross Cable Network	SCCN	2000	30500	1300000000	6	8	*	*	10	40	3.200	9.600
28	Tata TGN-Pacific	-	2002	22300	1700000000	5	16	*	96	10	10	3.140	15.360
29	Telstra Endeavour	-	2008	9125	n.a.	2	2	8	64	10	10	160	1.280
30	Thailand-Indonesia-Singapore (TIS)	TIS	2003	968	30000000	1	2	3	16	10	10	30	320
31	Trans-Pacific Express (TPE) Cable System	TPE	2008	17000	500000000	4	4	40	80	10	10	1.600	3.200
32	Unity	-	2010	9620	300000000	5	5	*	60	10	40	3.380	12.000
33	i2i Cable Network (i2icn)	i2icn	2002	3200	250000000	4	8	8	105	10	10	320	8.400
34	PGASCOM	-	2010	264	0	*	*	*	*	*	*	160	0
35	SAFE	-	2002	13500	290000000	2	2	*	*	10	10	440	440
36	Tata TGN-Tata Indicom	-	2004	3175	100000000	4	8	*	40	10	40	520	12.800

Source: Detecon, Telegeography

Figure 9: Active submarine cables in scope of the study

PLANNED SUBMARINE CABLE SYSTEMS IN THE APEC REGION

The boom in new cables to be deployed in this area has just begun. **Between 2012 and 2015 another 11 cable systems that have been announced may commence operation.** This will increase the deployed bandwidth considerably, especially because the new cables reflect the current state of the art in fibre optical transmission technology and are much more capable than earlier generations. Not all figures for the new cables’ capacities, costs and lengths are available yet, but according to research data, the cable capacity landing in Asia is expected to increase by another 60 Tbps, for an estimated cost of US$2.4 billion. 60,000 km of additional cables will come into service in the next two to three years[22].

This immense effort in deploying infrastructure will be almost entirely based on the initiative of private companies. Only in rare cases is there direct government or public agency involvement[23]. Hence, the above stated growing demand for bandwidth yields sufficient business opportunities to serve as the main driver for these players to invest heavily and continuously expand the worldwide submarine cable network.

[22] Asia ex-Japan submarine cables worth US$11-21 billion, The Business Times Singapore, 2011

[23] However, it has to be mentioned that a number of involved domestic telecommunication providers are still at least in part publicly owned.

Nr.	Cable Name	Abbreviation	RFS Year	Cable Length in KM	Construction cost in USD	Lit Fiber Pairs (Current)	Lit Fiber Pairs (Potential)	Lit Wavelengths per Fiber Pair (Current)	Lit Wavelengths per Fiber Pair (Potential)	Gbps per Wavelength (Current)	Gbps per Wavelength (Potential)	Capacity 2012 (Gbps)	Max Capacity (Gbps)
37	Southeast Asia Japan Cable (SJC)	SJC	2012	6700	250000000	*	6	*	64	*	40	960	15.360
38	Asia Pacific Gateway (APG)	APG	2014	10400	500000000	*	*	*	*	*	*	0	54.800
39	Asia Submarine Cable Express (ASE)	ASE	2012	7500	300000000	*	6	*	64	*	40	0	15.360
40	OptiKor	-	2013	3000	100000000	*	*	*	*	*	*	0	6.400
41	Australia-Singapore Cable (ASC)	ASC	2013	4800	160000000	*	2	*	80	*	40	0	6.400
42	Taiwan Strait Express-1 (TSE)-1	TSE-1	2012	260	30000000	*	8	*	*	*	*	0	5.120
43	Xiamen-Kinmen Undersea Cable	-	2012	21	29000000	*	*	*	*	*	*	0	9.600
44	Australia-Singapore Submarine Cable-1 (ASSC-1)	ASSC-1	2013	4600	0	4	4	40	40	40	40	0	6.400
45	Arctic Fibre	-	2013	15600	640000000	*	4	*	80	*	40	0	12.800
46	Arctic Link	-	2015	15840	1200000000	*	*	*	*	*	*	0	12.800
47	Russian Optical Transarctic Cable System	ROTACS	2014	17000	840000000	*	*	*	*	*	*	0	12.800

Source: Detecon, Telegeography

Figure 10: Planned submarine cables in APEC region

Geographic diversity by new cable routes between Europe and Asia through the Arctic Sea

One group of new cables will clearly yield immense benefits and has a spectacular route design. Three cable systems are currently under construction, which will **connect the Atlantic and Pacific regions through the Arctic Seas via the so-called North-West Passage north of Canada/US and North-East Passages north of Russia**. The Arctic ice cap has decreased sufficiently to permit the installation of fibre optical cable systems in these harsh environments. Cable installation ships, accompanied by icebreakers, are able to make the journey during the Arctic summer for the first time ever.

These new cable systems in particular will considerably improve overall network stability and resilience:

1. Firstly, because their route through the Arctic region **avoids areas which are infamous for being failure-prone "choke points" such as the Luzon Strait near Chinese Taipei, the Strait of Malacca between Indonesia and Malaysia, and the South China Sea as well as the Suez Canal,** where a single landslide or a ship dragging its anchor can break several cables, and disrupt the internet traffic. In addition, politically unstable regions in the Middle-East will be avoided by these cable systems.

2. Secondly, the cables **create an entirely new redundant route as a geographic alternative to the existing cables**. The likelihood of a blackout following a single disruption of several cables in one region – e.g. due to natural catastrophes like earthquakes or storms - is reduced considerably. Even if an event should damage several cables in region A, there would still be an alternative new route available in region B.

3. Thirdly, these new cables will **improve the network stability by following routes that are much less likely to be struck by the most common disruptions**, man-made hazards, as they are far away from traditional shipping and fishing routes.

A second major benefit in addition to increased overall network resilience will be a **reduced latency** for connections between Europe and Asia. As the cables will provide a direct, uninterrupted fibre optical connection, the speed of information will be considerably higher than with systems that need to interconnect the information from one cable to another using active equipment, which always creates delays of valuable milliseconds. Because the cables will run between two of the major financial hubs of the world, London and Tokyo, high-speed trading will profit massively. It may be assumed that this financial factor is the strongest driver.

The first of these cable systems to be finished next year will be the “Arctic Fibre” system spanning a 15,600 km network between Tokyo and London through the North-West Passage cutting the present round-trip time, or "latency", between both cities from 230 milliseconds to 168 milliseconds.
The second of these cable systems will be the Russian Optical Transarctic Cable System (ROTACS), whose construction shall be finished in 2014 and which takes the north-eastern route from Europe to Japan north of Russia. The third one called “Arctic Link” is said to be

ready for service in 2015[24] and will also connect London and Tokyo along the North-West Passage north of Canada and the US. It is expected to cost a staggering US$ 1.2 billion.

Easing geographic congestion for Australia and New Zealand by adding new routes

Another group of cable systems will create additional and, more importantly, geographically diverse connections for Australia and to some extent indirectly for New Zealand. As both economies are islands, they are entirely dependent on submarine cables for their participation in the global data network.

The Australian continent is currently mainly connected at the east coast with all cables landing in one regional beacon, the area around Sydney. This includes Southern Cross, Australia-Japan Cable, Telstra Endeavour and PIPE PPC-1. There is just one cable on the west coast, SeaMeWe-3, landing in Perth, but this is a relatively old cable built in 1999 with only a very limited capacity of 90 Gbps. Only two cables have a direct connection to the main sources of internet traffic: SeaMeWe-3 directly connects Australia and Europe and Southern Cross is the only direct connection to the US mainland. Additionally, Southern Cross currently accounts for more than 50 percent of both the lit and potential capacity to Australia. The situation is even worse for **New Zealand,** which is currently only connected by two cable systems: Southern Cross and Tasman-2. Both cables land at the very same spot near Auckland.

This high concentration in infrastructure and geography and the lack of alternative cables and routes constitutes a certain risk concerning loss of traffic and decline in connection speed and quality, as events such as earthquakes or storms could harm several cables at once.

Hence, additional redundancy and geographic diversity is needed in order to decrease risks from cable disruptions and to improve the overall network resilience. Such redundant routes are already planned or even under construction. However, all new routes for Australia will again land at the same two spots in and around Perth and Sydney and the only new route for New Zealand, OptiKor, will again make landfall in Auckland. **This high geographic concentration remains a risk.**

Unfortunately, one important planned Trans-Pacific connection, **Pacific Fibre**, has decided to cease operations and will not be built. This is a setback for Australian route diversification and especially for New Zealand.

Two cables are planned to be built on the **west coast** of Australia from Perth to Singapore: the Australia-Singapore Cable (**ASC**) and the Australia-Singapore Submarine Cable-1 (**ASSC-1**). Most probably only one of these cables will be built in the short term as two on the same route are unlikely to be economically viable. Either of these proposed west coast cables would provide the first major redundancy for the cables on Australia's east coast and the first major connection to South East Asia.

[24] Global Bandwidth Research Service, Telegeography, 2012

On the **east coast** the deployment of one new cable is proposed: **OptiKor**. This cable, however, only connects Australia to New Zealand and therefore only provides limited international redundancy.

New Zealand currently lacks sufficiently redundant and geographically diverse sea cable connectivity. Nevertheless, only limited efforts have been made so far to change this potentially risky situation. The one major additional cable project to cross the Pacific, Pacific Fibre, was aborted as described above. OptiKor is currently the only additional cable planned, but this only connects New Zealand to Australia and again makes landfall in Auckland.
A second direct link for New Zealand to the US could end New Zealand's critical situation of being dependent on a single major cable, which represents a high risk of being cut off from the world in case of disruption.

Reducing risks at the Luzon Strait for Chinese Taipei using new direct cable links to China

As will be described in detail in Chapter 2, the Luzon Strait between Chinese Taipei Island and Luzon Island (Philippines) is an area of high cable density but also of frequent disruptions as it is very prone to earthquakes.

Virtually all important cables linking Chinese Taipei to the world go through this choke point. The high geographic concentration of cables and a lack of alternative cables and routes imply a certain risk of loss of traffic and decline in connection speed and quality, as events such as earthquakes or storms may harm several cables at once. This has in fact already happened several times. The impact was especially severe after the heavy earthquake which took place in the area in 2006. It damaged and disrupted almost all cables in the Luzon Strait and cut off Chinese Taipei from the worldwide web for several days.

Hence, additional redundancy and geographic diversity is needed in order to decrease risks from cable disruptions and improve the overall network resilience for Chinese Taipei. This will to some extent be provided by a new cable that will directly link Chinese Taipei and China between Xiamen and Kinmen.

The **Kinmen-Xiamen Submarine Cable** is designed to have a bandwidth capacity transmission speed of 9.6 Terabits per second, which will be further increased according to telecommunications needs. The project was scheduled for completion by March 2012 and the total construction cost is estimated at around US$14 million. The cable will be constructed in a cycle structure and consists of two sections to increase resilience: an 11km work route and an 8.5km protective route. Each section of the submarine cable will contain 12 fibre-optic pairs of 80 wavelengths - and each wavelength will have a bandwidth capacity transmission speed of 10 Gigabits per second[25].

But there are more cable deployments under way which will further increase the geographic diversity: The Chinese telecommunication company FarEasTone is applying to the Chinese National Communication Commission to deploy another direct submarine cable link between Fujian Province in China and Tamshui in Chinese Taipei through the same regulatory approval procedure as used for the Kinmen-Xiamen Submarine Cable. According to

[25] NCC approves submarine cable link between Chinese Taipei and China, China Telecom, 2011

FarEasTone, in the past much of the bandwidth introduced by global telecommunications operators into China was provided using land cables from Hong Kong, China. FarEasTone is hoping that as a result of the submarine cable deployed between Tamshui and Fujian global telecommunications operators will be attracted to link with China through Chinese Taipei, thus elevating the region's status for telecommunications service provision in Asia. [26]

However, it should be noted that most cables in the Luzon Strait are of a bigger, regional importance and do not only serve Chinese Taipei. These cables are still at significant risk and need additional geographically redundant routes as will be explained in more detail in Chapter 2.

Upgrading existing cables

Submarine cables are always deployed with excess capacity to accommodate significant increases in bandwidth demand. The total potential or the equipped capacity of a submarine cable is given by the sum of its lit and unlit capacity. Lit capacity is the capacity of the fibres that are activated and are being used for data transmission. Unlit capacity is determined by the potential of the dark fibres that are currently not used for transmission. In 2009, it was estimated that at this point of time worldwide only 30% of the submarine cables' potential capacity was lit.[27]

Upgrading however means that the cable's potential bandwidth capacity can be enhanced, typically by increasing the transmission speeds per wavelength. Upgrading existing cables and increasing their capacities - often several fold - is an important element in increasing international bandwidth.

A typical upgrade currently taking place for several cables is from 10 Gbps to 40 Gbps in a dense wavelength division multiplexing (DWDM) cable - this leads to a fourfold increase in capacity.

One example is NEC Corporation which has completed a multi-million-dollar contract with a purchasing consortium of 14 telecom operators in the Asia Pacific region for a 40Gbps DWDM capacity upgrade to the existing APCN2 (Asia Pacific Cable Network 2). The cable of over 19,000 km that connects 10 landing stations in the Asia Pacific region was originally supplied by NEC in 2001 with a 10Gbps system design. In response to the rising transmission demands in the region, NEC proposed its 40Gbps technology as an enhancement.[28]

This is currently happening all over the world and provides help coping with the surging need for additional bandwidth without being forced to deploy new cables at much higher costs.
For the overall network performance this should be encouraged and supported by member economies wherever possible.

However, it has to be noted that **this approach does not necessarily increase the resilience of the network.** New, additional capacity allows for easier rerouting via other cables in case of a disruption; contributing to a better network resilience. **But in some areas and for certain choke points, where there is a shortage of redundancies, i.e. enough different available routes via different cables, rather than just a shortage of capacities, upgrading**

[26] NCC approves submarine cable link between Chinese Taipei and China, China Telecom, 2011
[27] Submarine Cable Networks Outlook, Frost & Sullivan, 2009, page 9
[28] NEC completes 40Gbps capacity upgrade contract in Asia Pacific, Datamonitor NewsWire, 2011

existing cables does not solve the problem. Only new cables, ideally in geographically diverse locations, will create sufficient redundancy for critical cases such as when natural disasters disrupt several cables in a certain region.

2. DANGERS TO AND DISRUPTIONS OF SUBMARINE CABLE SYTEMS IN THE APEC REGION

REASONS FOR CABLE DISRUPTIONS

With the world so dependent on cable systems, the technology deployed needs to be among the most reliable in the world. Industry figures claim that cables operate with up to "5 nines" reliability - i.e. 99.999 percent of the time. Only highly critical systems such as space shuttle technology and nuclear weapons security have similar reliability[29]. But if all cables are taken into account, submarine cable disruptions are still far from being an unlikely or rare event.
In fact they happen quite often in absolute numbers. As a technology system with physical, logical, and human components, cables are a high-risk, single point of potential failure[30]. **Hence, submarine cables, although technologically advanced, are susceptible to damage.**

Cable systems may be disrupted for a number of reasons, each of which has a different profile in terms of the probability that their occurrence could damage the overall network performance of an economy. Some types of damaging events are relatively common but usually only affect single cables and do not cause a real threat to the overall performance of an economy, whereas other forms of damaging may be quite unlikely but then affect several cables and thereby pose a real threat to modern societies and economies which are increasingly dependent on the functioning of the global data network.

The hazards to submarine cable-bound communication can be categorized **into three groups**:

1. natural hazards to the cables themselves,
2. man-made hazards to the cables themselves, and
3. hazards to the remaining infrastructure, especially landing stations, maintenance ships and IT network management systems.

Natural hazards to submarine cables

Natural causes for cable disruptions are quite unusual. They include current abrasions and earthquakes which **cause around 12% of all faults**[31]. O**nly in water depths of more than 1000 m** are they the **major cause** of damage to submarine cables[32]. However, when they happen they **usually cause devastating damage, often to a large number of cables**. This makes them much more hazardous to the overall network performance than those hazards which affect only single cables. Typical events in this category are[33]:

- Submarine earthquakes, fault lines and related landslides break or bury cables
- Density currents break or bury cables
- Currents and waves cause abrasion, stress and fatigue of material
- Tsunami, storm surge and sea level rise cause damage to coastal installations

[29] New threats, old technology, Michael Sechrist, 2012, page 9
[30] New threats, old technology, Michael Sechrist, 2012, page 8
[31] About submarine telecommunications cables, ICPC, 2011
[32] About submarine telecommunications cables, ICPC, 2011
[33] About submarine telecommunications cables, ICPC, 2011

- Extreme weather (e.g. hurricanes) breaks or buries cables
- Rarely icebergs or volcanic activities cause damage to cables

Earthquakes and undersea landslides are especially hazardous to submarine cables as they may hit submarine cables at any location along their routes, even at great marine depths. The amount of damage that an earthquake and subsequent undersea landslides typically cause is often very severe - meaning a full rupture of a cable and this along longer parts of the cable. In deep water submarine cables are much less armoured and protected than in areas close to land - which will be described further in Chapter 4 - and are therefore especially vulnerable. In addition, it is more difficult and takes longer to repair submarine cables which are damaged in deep water. The special threat related to earthquakes stems from the fact that **they affect large areas and usually damage all cables running through the affected area.**

Storms like typhoons can cause serious damage to submarine cable systems as well. Such events affect cables by flooding coastal facilities, triggering submarine landslides and forming strong, eroding currents and waves. However, as they only unfold their destructive power above and just below the sea level, they tend to hit submarine cables at a point close to land where these are typically well protected by being buried into the seabed and thus less vulnerable. Still, such storms have enormous destructive powers and may cause the full rupture of a cable, often along great lengths of the cable.

Similar to earthquakes, the special threat lies in the fact that **they affect large areas and may therefore damage several cables at the same time.** This is especially dangerous in combination with the fact that storms hit cables close to land. Cables which run separately and at wider distances under the ocean may converge close to the shore to reach the same landing station and are therefore more likely to be hit commonly by such an event.

Damages done by **aquatic wildlife** are **no longer a danger**. Published cable fault data show that from 1877 to 1960, 16 whale entanglements were noted. Since then none have been registered. In the history of submarine cables there have been at least 40 cable faults caused by sharks and “fish” bites. But these faults were also restricted mainly to telegraph cables before 1964. This change may in part be due to improved materials and laying techniques. Compared to telegraph cables, modern cables are strong, deployed under tension with less slack, and are often buried below the seabed in water depths up to 2000m.[34]

Man-made hazards to submarine cables

In comparison to natural hazards, man-made causes for submarine cable disruption count for the **far larger number of events and are more likely to occur. Around 70% of all cable faults are caused by fishing and anchoring in depths of less than 200 m**[35]. In water depths of less than 1000 m human activity is the main hazard to submarine cables, natural impacts cause less than 10% of cable damage in this area.

Globally, 100-150 cables are broken per year by fishing or anchoring. **However, each event typically only affects a single cable which makes them less dangerous for the overall network performance.** Events in this category can be distinguished into negligent and intentional damaging of submarine cables.

[34] About submarine telecommunications cables, ICPC, 2011
[35] About submarine telecommunications cables, ICPC, 2011

- By far the biggest proportion of events is due to **negligence**. This is the result of **fishing** boats dragging their nets along the seabed, any type of ship dropping and dragging its **anchor,** or **dredging** of the seabed. According to data from 544 faults saved in the ICPC Fault database (status 2009) these incidents are the major cause (60%) of cable disruption[36].
- The **intentional** damaging of submarine cables can be ordinary **theft**, aimed at the cable materials. Alternatively, it can be **sabotage or even terrorism** and aims at disrupting communications using the cable. This threat has to be taken very seriously. The imbalance between the vulnerability of submarine cables on the one hand and the possible impact of their disruption on the other hand makes them an especially interesting target for terrorists.

  Recently the Singapore ambassador to the UN, Ambassador Menon, stated: "If an accident, or worse, a deliberate, well-planned act of sabotage knocks out a key node or portion of these cables, economies and even whole regions could suffer massive economic losses, social disruptions and compromises to domestic security."[37] However, as there is considerable redundancy throughout the system, as the model in Chapter 3 shows, causing massive impacts on the overall economy would usually require simultaneous attacks on multiple cable systems.

Man-made hazards typically only affect those parts of the cables which are close to land and where they are in relatively shallow water and therefore in the range of ships' nets and anchors. By far the most disruptions happen in depths of less than 200 metres. This additional vulnerability is countered by armouring the cables and burying them in the seabed. And if damage should take place, it is much easier to repair cables in these locations.

Although incidents caused by man-made hazards occur much more often than naturally caused ones, they are much less of a threat to the overall network performance as they typically only affect a single cable at a time.

Hazards to landing stations, maintenance ships and the IT environment

Interestingly, most debates and publications about dangers to submarine cable systems only focus on the cables themselves. However, since the cable infrastructure constitutes just one component of the overall communications system, other parts of the network have to be taken into account as well.

Cable landing stations

At **cable landing stations** cables make landfall, are received and connected to the land based core telecommunication network of, for example, a telecom provider. These cable landing stations typically cluster several cable systems at a single geographic point. The potential impact on the overall network performance from damage to such a landing station is therefore significant. Possible threats particularly include natural ones like **earthquakes and storms**

[36] Industry Perspectives – Submarine Cable Disruptions and the Risk to Trade & Investment, Peter Brouggy, 2012
[37] Guard the submarine cables that link us all, Tara Davenport, 2010

which may hit and destroy a cable landing station and all the cables linked to it. But it also includes man-made hazards, in particular intentional ones like **sabotage and terrorism**.

The U.S. State Department listed the **world's cable landing sites as among the most critical of all infrastructures** for the United States: by gaining access to terminals located within cable landing sites, or to the control systems managing the fibre-optic wavelengths, a hacker could acquire control over portions of international data and voice traffic and, potentially, have the power to disrupt or degrade significant portions of an economy's cyber infrastructure[38].

The destruction of an entire landing station, its equipment for interconnecting with the land based networks, and the multiple submarine cables bridgeheads in it could constitute a real danger to the overall network performance of an economy. In addition to this, the repair and reconstruction of an entire station and all its equipment may take much more time and effort than that of repairing a cable.

IT systems

A second piece of infrastructure which is very important for the overall network performance - and which is often neglected in the public attention - is **the IT or logical infrastructure used to manage, supervise and control the communication network the cables are part of**. There are an increasing number of cable operators using remotely-controlled network management systems which bring an additional risk[39].

The main hazard is man-made action which intentionally aims at damaging these systems either by physically destroying their underlying infrastructure (servers, connections) or more probably by large-scale cyber attacks. These kind of attacks have the biggest potential to cause damage as they would not only affect the single or multiple cables which are directly connected to the attacked network management systems, but may even damage and shut down the entire communication network in an economy.

Experts warn about the vulnerabilities of undersea communication cables, which today transport nearly all of the world's data and voice traffic, to cyber attacks[40]. They raise awareness to the fact that the long-standing physical vulnerability of cable infrastructure has now been compounded by new risks found in the network management systems that monitor and control cable operations. "Unlike an attack on a water treatment plant's control systems, however, an attack on the cables' control systems could devastate the world's economies – presenting a different kind of internet "kill switch" altogether – shutting down world commerce, and doing it all with the click of a mouse."[41]

Additional dangers inflicted by global warming

Global warming, caused by human activities, may have coincidental positive side effects for the submarine cable business such as newly arising opportunities to deploy cables in the

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[38] New threats, old technology, Michael Sechrist, 2012
[39] New threats, old technology, Michael Sechrist, 2012
[40] New threats, old technology, Michael Sechrist, 2012
[41] New threats, old technology, Michael Sechrist, 2012

Arctic Sea as explained in Chapter 1. However, it mainly has negative consequences and exposes the cables to new hazards due to:[42]

- rising sea level due to thermal expansion of oceans and melting ice
- increased windiness and wave/current activity
- more and more intense storms, rainfall and floods especially in coastal areas (where landing stations are located)
- changes in offshore activities, e.g. growth of renewable energy schemes.

POSSIBLE SCARCITY OF REPAIR VESSELS

An additional danger to submarine cables and the overall network performance of a member economy is the lack of repair vessels, their insufficient availability or their unequal distribution resulting in longer repair times for disrupted cables.

Maintenance and repair vessels are indispensible for the functioning of submarine cable systems. Every cable may be damaged at some point in time, as disruptions will never be entirely preventable. The cable may also need regular maintenance like every other man-made technical facility being exposed to intensive natural forces.

It is the operators' responsibility to repair submarine cables and provide a sufficient number of repair vessels. However, this may not always happen in the optimal way due to the high costs of such vessels. Hence, there are good reasons for member economies to increase their monitoring of the issue of repair vessels as an integral part of cable protection and impact mitigation.

The fast availability of these repair vessels is not necessarily guaranteed for every submarine cable and in all regions. The ships are quite expensive and therefore operators may not be willing to maintain the highest possible availability level. To reduce expenses vessel pools and mutual maintenance agreements are concluded between operators which stipulate certain response times. In general, this is a wise thing to do and should be supported by member economies. The task of cable repair is generally managed in an economic and efficient way by the operators. Operators have an incentive to repair cables as fast as possible as these are the source of their revenues and they have to fulfil contractual obligations towards their customers. They have to find a balance between the cost of optimal availability and minimized repair times on the one hand and longer repair times meaning bigger potential losses in case of a cable disruption on the other.

However, from the operator's point of view this balance may tend too far towards avoiding the high costs of repair vessels and thus accepting relatively long repair times. These repair times may be too long from the member economy's perspective, whose chief aim is to minimize repair times to protect overall network performance and the economy's economic wellbeing.

Hence, member economies should be aware of the importance of cable repair ships and support and facilitate their availability and operation wherever possible. This includes abolishment of permit requirements for cable repair works as these requirements delay

[42] About submarine telecommunications cables, ICPC, 2011

the repair process substantially. In addition, member economies should be informed about the availability of repair vessels in their vicinity so that they can monitor the situation and act accordingly to prevent a lack of vessels that could delay cable repair.

POSSIBLE EFFECTS AND PARTIES AFFECTED BY CABLE DISRUPTIONS

Nothing can substitute submarine cable systems from a global perspective. In the event of a catastrophic failure of the entire or even only regional parts of the cable architecture, satellites and other technologies would only be able to substitute a tiny share of the cables' capacity. Cable disruptions could result in the complete loss of regional network transmission or, when redundancy or back-up capacity is available, reduced or congested network access.

As shown in Chapter 1, the ubiquitous reliance of businesses across all industries on internet and international communications means that subsequent cascading impacts could result in severe and widespread economic loss to the affected member economies. These **indirect costs caused by the disruption of submarine cables pose the main threat to member economies**. **Their value will therefore be examined in detail in the Economic Impact Model described in Chapter 3.**

There are also **significant direct costs**, often accounting for hundreds of thousands of dollars, sparked by the repair and recovery of damaged cables. These costs, combined with temporarily loss of cable revenues, are a severe **burden for the cable operators** and are their main incentive to protect the cables and prevent damages as described in detail in Chapter 4.

However, if compared to the potential indirect losses for the whole economy as shown in Chapter 3, theses direct costs are still relatively small. Therefore, from a macro-economic point of view, there may be an imbalance between the cable operators' level of incentive to invest in cable protection and impact mitigation and that of the member economies. This will be described in detail in Chapter 4.

PAST DISRUPTIONS IN THE APEC REGION

The APEC region around the Pacific is a vast territory including some of world's **busiest shipping routes and fishing areas**. **The area is especially prone to natural hazards like storms and earthquakes**. In combination with the dense network of submarine cables running here, as shown in Chapter 1, it is not surprising that submarine cable disruptions are quite a common event. There is a constant high number of occasional **single cable faults,** typically caused by the most man-made hazards of anchors, fishing nets and dredging activities.

However, the rare but particularly severe natural disasters that cause disruptions to several cables concentrated in one area are of special interest for the economic impact analysis in Chapter 3. These events are particularly likely to exceed existing redundancies, to diminish capacities considerably, and thereby cause traffic outages leading to economic damage in the affected member economies.

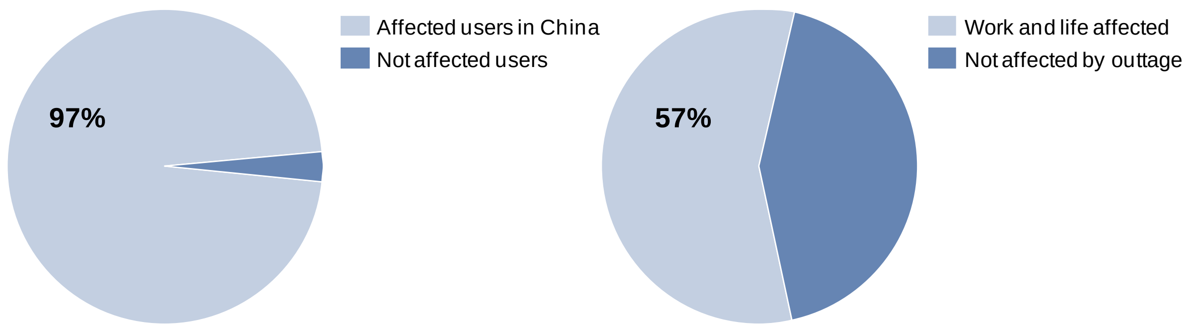
In recent years there were **two major incidents** which considerably affected submarine cables and damaged several: the earthquakes in 2006 in Chinese Taipei and in 2011 in Japan. Most interestingly, the effects and the resulting impact on traffic and therefore economies were rather different: the impact in 2011 was much smaller. This might have been due to the different areas which were just differently well prepared but may also show that there is increasing network resilience and that redundancies are progressively reducing risks of outage.

Earthquake in Chinese Taipei in 2006

The first of the events was the great Hengchun earthquake on the island of Chinese Taipei and the neighbouring Luzon Strait on 26th December 2006. It was probably the most severe example in recent history, showing the massive social and economic impacts cable outages can have and stressing our dependence on this infrastructure and its importance for our economic well-being.

The earthquake triggered a submarine landslide near the junction of two tectonic plates. The landslide and subsequent turbidity current travelled over 330 km and **caused 19 breaking points in seven cable systems.** Damages were located in water depths to 4000 m and even undamaged cables were locally mud covered. **The cable repair works involved 11 repair vessels and took 49 days.**[43]

The **result was a major disruption of services in the whole region**, with Chinese Taipei being hit the hardest. The massive traffic outages affected data and voice, consumers and businesses[44]. The internet connections for China, Hong Kong, China, Viet Nam, Chinese Taipei, Singapore, Japan and the Philippines were seriously impaired. Banking, airline bookings, email and other services were either stopped or delayed and financial markets and general commerce were disrupted. Although most traffic was quickly re-routed via undamaged cables, some delay was still apparent even two months after the earthquake.[45] However, the attempt to suddenly re-route most of the affected traffic led to further failures in neighbouring cable systems. Following a survey in China, 97% of Chinese internet users had problems visiting foreign websites and 57% felt that their life and work was affected[46].



Source: sina.com

Figure 11: Consequences of earthquake for China

This event clearly **showed the massive lack of redundant submarine cables in that area, which were in particular not geographically diverse enough but instead all concentrated in one hazardous area.** It took several days to stabilize the traffic but it was even then still

[43] Critical Infrastructure Submarine Telecommunications Cables, ICPC, 2010
[44] Submarine Cables in Asia, Ovum, 2008
[45] Critical Infrastructure Submarine Telecommunications Cables, ICPC, 2010
[46] Beben beschert Rückfall ins Telefonzeitalter, Nordkurier, 2006

impeded by speed and reliability at only half of the worldwide average[47] and considerably below what Chinese Taipei is used to. Commentators called it "a fallback into the telephone age" and "a collapse of the virtual world" [48]. It took weeks to repair the first cable and recover speed and reliability to an acceptable level.

The **economic impact** of such a severe blow to the island's overall data connectivity, especially in case of Chinese Taipei with its highly developed and therefore highly connectivity-dependent economy, **was enormous**.

Earthquake in Japan in 2011

The second major event was the great seaquake close to Japan's east coast in March 2011. This natural disaster was one of the strongest earthquakes ever seen, measuring 8.9 on the Richter scale, and it and the devastating tsunami it caused, both broke several submarine cable systems. However, the **effects on traffic were considerably smaller than 5 years before in Chinese Taipei**. While there was some disruption to international communications due to several reported cable breaks, **international connectivity was surprisingly robust**[49].

Although roughly half of the trans-Pacific cable capacity was crippled, some of the other cable systems took the load of those cables that were down[50]. Overall, **telco network carriers were able to re-route most of the affected traffic to avert major disruption to services**.

Keynote Systems, a mobile and internet monitoring firm, also said it found very few problems at a macro level for Japan's internet although some leading Japanese sites struggled to stay available. Access between Tokyo and regional hubs including Seoul, Singapore and Chinese Taipei, as well as San Francisco, was not affected either[51].

This was principally **due to the wide geographic diversity of Japan's submarine cable network and the multitude of landing stations on different coasts**. This shows once again how **important well planned diversity and redundancy of the cable network** are in cases of need. With well-conceived private and public contingency planning for emergency situations, traffic outages and economic impacts can be almost entirely prevented, even from major events.

Conclusions to be drawn from the disasters

1. The ability to repair the affected submarine cables was impeded by the fact that most Japan-based **cable repair vessels were hit** either by the earthquake or the tsunami. **Geographic diversity and proper protection of these vessels is therefore crucial for the overall network reliance and resilience**.

2. These disasters showed once again that submarine cables and their use and protection are **not a single economy's task but should be tackled in a multilateral approach**. By

[47] Beben beschert Rückfall ins Telefonzeitalter, Nordkurier, 2006
[48] Beben beschert Rückfall ins Telefonzeitalter, Nordkurier, 2006
[49] Japanese earthquake: impact on the telecoms network, Ovum, 2011, page 2
[50] Pacnet to launch data centre in December - Asia's largest submarine cable network provider targets rising demand for cloud-computing services, South China Morning Post, 2011
[51] Japans internet holds up despite the quake and tsunami, VentureBeat, 2011

nature these systems cross territorial borders and a fault at one point might affect all others along the way as well. For instance, after the 2006 earthquake Hong Kong, China based internet users visiting overseas websites experienced slow network connections and congestions as well. So even if one member economy takes all necessary steps it is still dependent on the efforts of others – or may profit if others do more.

3. **Not all cable operators showed the necessary degree of transparency and cooperation**. Pacnet, which ran Asia's largest privately owned undersea cable network in 2011, and Pacific Crossing, a unit of NTT Communications, both made the damage caused by the earthquake in their respective cable systems public. Other cable system operators kept largely quiet[52]. For a combined public-private contingency and impact mitigation planning to work well, this cooperation is crucial. A partial lack of voluntary cooperation on the operators' side may lead to a call for mandatory measures instead, which is understandable when considering the importance of the issue for the overall economy.

[52] Operators scramble to repair undersea cables - Telecoms network carriers re-route internet traffic, South China Morning Post, 2011

No.	Cable	Date	Duration	Reason
1.	China-US. Cable Network	February-01	2 Weeks	Fishing nets
2.	China-US. Cable Network	March-01	n.a.	Fishing boat anchor
3.	Cable near China	September-01	n.a.	Fishing boat anchor
4.	Southern Cross Cable Network	July-01	12 Days	Bout of bad weather
5.	APCN-2	June-06	1 Week	Undersea quake
6.	Se-Me-We 3	December-06	3 Weeks	Hengchun Earthquake
7.	Se-Me-We 3	December-06	3 Weeks	Hengchun Earthquake
8.	APCN	December-06	2 Weeks	Hengchun Earthquake
9.	APCN	December-06	2 Weeks	Hengchun Earthquake
10.	CUCN	December-06	2 Weeks	Hengchun Earthquake
11.	CUCN	December-06	2 Weeks	Hengchun Earthquake
12.	CUCN	December-06	2 Weeks	Hengchun Earthquake
13.	APCN-2	December-06	2 Weeks	Hengchun Earthquake
14.	APCN-2	December-06	2 Weeks	Hengchun Earthquake
15.	REACH North Asia Loop	December-06	1 Week	Hengchun Earthquake
16.	Flag Europe Asia (FEA)	December-06	3 Weeks	Hengchun Earthquake
17.	T-V-H	March-07	3 Month	Theft
18.	Se-Me-We 4	February-08	2 Weeks	Fishing nets
19.	Se-Me-We 4	December-08	1 Month	Fishing boat anchor
20.	Se-Me-We 4	December-08	1 Month	Fishing boat anchor
21.	Flag Europe Asia (FEA)	December-08	2 Weeks	Fishing nets
22.	APCN	August-09	10 Days	Typhoon Morakot
23.	APCN	August-09	10 Days	Typhoon Morakot
24.	Se-Me-We 3	August-09	10 Days	Typhoon Morakot
25.	Se-Me-We 3	August-09	10 Days	Typhoon Morakot
26.	Se-Me-We 3	August-09	10 Days	Typhoon Morakot
27.	CUCN	August-09	10 Days	Typhoon Morakot
28.	APCN-2	August-09	10 Days	Typhoon Morakot
29.	EAC-C2C	August-09	10 Days	Typhoon Morakot
30.	APCN	March-10	2 Days	Jiaxian Earthquake
31.	APCN	March-10	2 Days	Jiaxian Earthquake
32.	Se-Me-We 3	March-10	2 Days	Jiaxian Earthquake
33.	CUCN	March-10	2 Days	Jiaxian Earthquake
34.	CUCN	March-10	2 Days	Jiaxian Earthquake
35.	APCN-2	March-10	2 Days	Jiaxian Earthquake
36.	Se-Me-We 4	April-10	4 Days	Shunt fault
37.	APCN-2	March-11	2 Weeks	Earthquake Japan
38.	Pacific Crossing -1 (PC-1)	March-11	n.a.	Earthquake Japan
39.	East Asia Crossing	March-11	n.a.	Earthquake Japan
40.	Asia-America-Gateway (AAG)	March-11	n.a.	Fishing boat anchor
41.	Asia-America-Gateway (AAG)	August-11	n.a.	Shunt fault
42.	Asia-America-Gateway (AAG)	August-11	n.a.	Fishing nets
43.	Asia-America-Gateway (AAG)	October-11	1 Month	n.a.
44.	i2i-cable	December-11		
45.	Se-Me-We 3	December-11		
46.	Se-Me-We 3	February-12		Mysterious Circumstances

Source: Detecon

Figure 12: Table of submarine cable disruptions (as far as publicly known)

REGIONS SUBJECT TO SPECIAL HAZARDS (CHOKE POINTS)

There are several regions in the APEC region which are infamous for the high number of cable disruptions occurring there.

This is **mainly due to two factors** which coincide in an unfortunate way:

1. The **multitude of cables deployed in these typically narrow geographic corridors**: This fact increases the likelihood that one or several of the cables may be hit by any of the typical threats depicted above. When any incident strikes these areas, the high density of

cable and the lack of geographic diversity and redundancy along different routes probably lead to severe outages for the service recipients.

2. **These areas are especially prone to specific dangers**, which in combination with the first factor dramatically increases the likelihood of cable damages.

In general there is a good overall linkage of intra-Asia connections and there is considerable redundant capacity to the US and to a smaller extent to Europe. However, capacity redundancy must not be confused with **geographic diversity** which is probably even more important for impact mitigation and network resilience and there are **some severe bottlenecks in this regard in the APEC region.**

Redundancy means the availability of either spare capacity on one or several cables or of different cables on a certain route offering substitution for each other in case of disruption. However, redundancy does not necessarily mean that these cables have a geographically diversified routing. Several cables providing redundancy to each other could all run along exactly the same route. Hence, especially in case of natural disasters which typically affect larger geographic areas, all these closely deployed cables may be disrupted at once and thereby thwart the positive effects of the intended redundancy.

There are some regions in the APEC footprint where there is strong redundancy, i.e. a multitude of cables running along the same route, but where geographic diversity is missing. These areas are generally called **choke points** and the presence of several cables running closely to one another makes them especially susceptible to risk:

The Strait of Malacca between Malaysia, Singapore and Indonesia

This narrow sea-corridor has a large number of submarine cables all running along the same route. **Fourteen of the 37 submarine cables in scope of this study run through the narrow Strait of Malacca.** These cables represent **virtually the entire data connection between** Asia, India, the Middle East and Europe. In addition, it is one of the **busiest shipping routes worldwide** - drastically increasing the likelihood of disruptions by anchors and other man-made hazards. And these disruptions unfortunately do happen regularly.

Any bigger events like an earthquake could have potentially severe effects on this connection resulting in traffic outages or decreased speed and reliability.

It is therefore recommended that a redundant geographically diverse route is created for this region, e.g. an overland route cutting through Thailand, avoiding the Strait entirely.

The Strait of Luzon between Chinese Taipei and the Philippines

An equally large number of submarine cables is deployed in this wider corridor between the islands of Chinese Taipei and Luzon (the Philippines). It is the major route for cables coming from Singapore and Hong Kong, China, on their way to the Pacific and to the USA**. Nine of the 37 submarine cables in scope of this study run through the Strait of Luzon**. The major problem of this area is its **increased susceptibility to severe earthquakes** as it is just on top of several tectonic plates. A natural disaster could have severe effects on submarine cables resulting in traffic outages or decreased speed and reliability. The major earthquake in Chinese Taipei in 2006 drastically highlighted this vulnerability.

It is therefore strongly recommended that a redundant geographically diverse route is created for this region. The obvious alternative route through the Strait of Formosa is not recommended as it is rather narrow and very shallow (around 70m) whereas the Luzon Strait is up to 3000m deep. Going south of the Philippines is not feasible as this route is too long and does not match latency requirements. **It is therefore recommended to build an overland route cutting through the island of Luzon (the Philippines), avoiding the Strait entirely.**

There are currently several cables under construction which may already deliver some geographic diversity as they run further to the south of the Strait than most cables currently do. However, they are still inside the Strait and may therefore be damaged by any seaquake.

The South China Sea

This area between the Strait of Malacca and the Strait of Formosa is framed by China; Hong Kong, China; Chinese Taipei; the Philippines; Indonesia; Malaysia; Brunei Darussalam; Singapore; Thailand and Viet Nam. It is the routing corridor **for most submarine cables in scope and at the same time the major shipping and fishing area for hundreds of millions of people.**

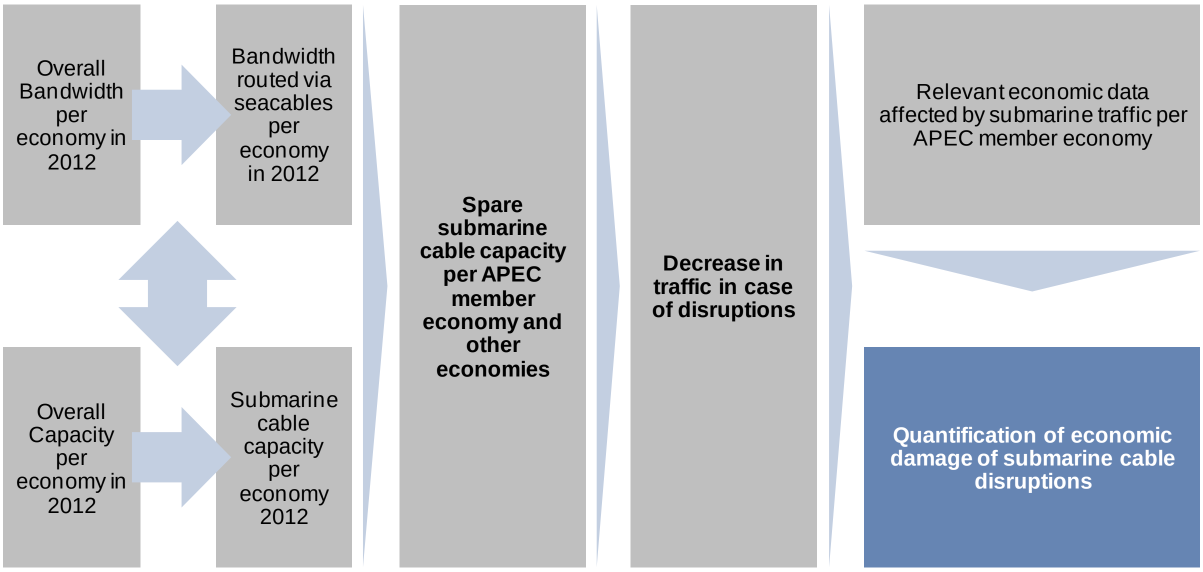
Very similar to the Strait of Luzon, the major problem of this area is its susceptibility to severe earthquakes, whose damaging effects could result in traffic outages or decreased speed and reliability.

It is therefore recommended that redundant geographically diverse routes are created through or around this region in order to decrease cable concentrations and possible traffic outages following disruption of multiple cables. As the shortest and cheapest routing is still preferred by operators, this leads to a high cable concentration. This can be explained by the operators' individual economic motivation (see Chapter 4) but requires that affected member economies give more attention and a higher priority to network resilience and the creation of geographically more diverse cable routing.

3. ANALYSIS OF THE ECONOMIC IMPACT OF SUBMARINE CABLE DISRUPTIONS

MODELLING APPROACH

In order to analyse the economic impact of submarine cable disruptions, Detecon has built a comprehensive model of international traffic and capacity in the Pacific region. Based on current economic data and loss in traffic this was then translated into economic effects as illustrated below.



Source: Detecon

Figure 13: Model Dynamics

Detecon opted for this approach as it is based on a detailed analysis of current capacities and traffic requirements in the region. This significance of actual traffic figures for the model constitutes its advantage over other approaches. Furthermore, it examines every single APEC member economy and provides a complete picture of possible bottlenecks and choke points in the overall submarine cable network. **Only after the analysis of capacities and traffic has taken place is potential traffic loss associated with costs (refer to worksheet "Costs").** Thus, the **results provide a deep insight into the submarine cable network as well as an estimation of costs associated with outages.** This methodology reflects the major research objectives of this particular project: to identify bottlenecks and risks in the submarine cable network and associate these with economic costs in case of outages.

Traffic Analysis

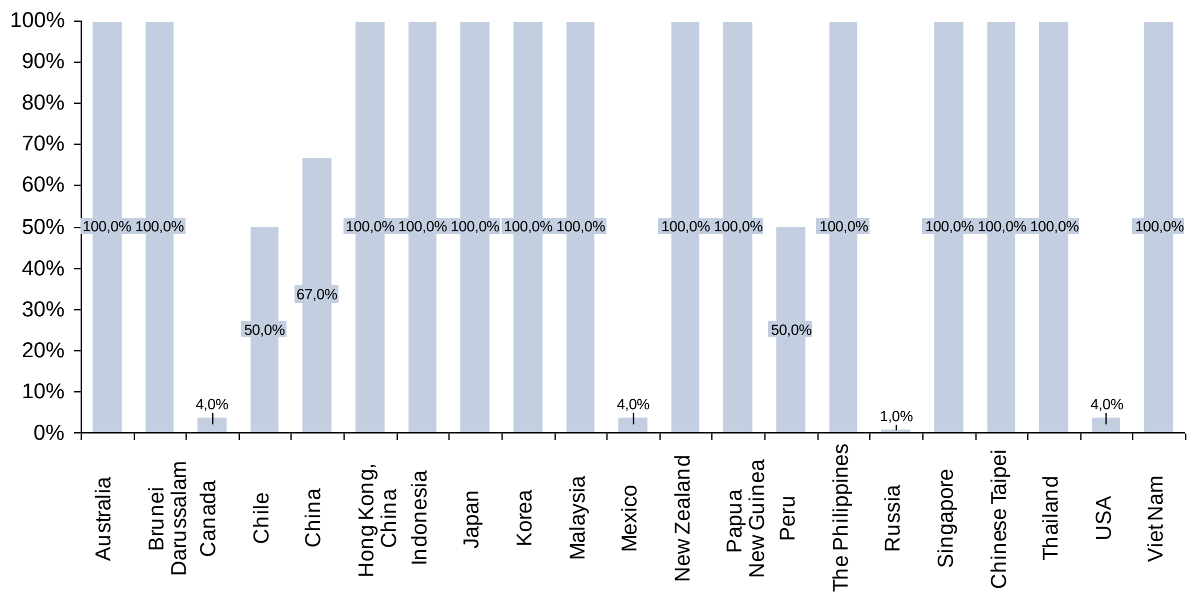
The entire model is based on the analysis of traffic. Taking into account required **bandwidth (demand) in 2012 and 2018** as well as **capacity provided (supply)** by current and planned submarine cables, a detailed analysis was performed as to whether each economy has the required capacity. Then, the model allows the "switching off" of individual cables or landing stations in order to model the effects of a cable disruption. This shows whether there will still be sufficient capacity available per member economy after single or multiple parts of the overall submarine cable infrastructure have ceased operations due to damage. This is done in the worksheet "Cockpit".

It should be noted that the model is based on available capacity per APEC member economy and ignores the need for routing in order to control for complexity. For the same reason, domestic traffic has generally been ignored, even though this may (or even must) also be transported via submarine cables or may even be required by some economies' geographies as in Indonesia or Malaysia.

Furthermore, the network in the APEC region is characterized by a sufficient density of submarine cable systems assuming that capacity will be sufficiently available on the route required as long as there are no major outages in two to three critical areas - which will be analysed separately. The bottleneck is thus really the availability of sufficient capacity per member economy as opposed to overall capacity in the network. **Main input parameters for this part of the model are capacity and bandwidth required per member economy**.

Capacity assumptions are based on Telegeography data, the leading global database for international traffic and connectivity. This is also the reason for the choice of 2018 as the final year for analysis: it is the last year for which Telegeography currently provides traffic forecasts. Submarine cables are assumed to make their full present capacity available to each member economy where they land. 2018 capacity was calculated using the maximum potential capacity of current and planned cables based on current technical set-up.

Traffic assumptions are based on international bandwidth forecasts and current figures, both corrected for traffic transported via overland cables or cables out of scope of the model, e.g. Trans-Atlantic cables. Therefore detailed assumptions were made for each APEC member economy based on Detecon's expertise in international bandwidth markets:



Source: Detecon

Figure 14: Proportion of international traffic transported via submarine cables

Particular cases

Island member economies: Economies which are islands, isolated continents without an overland connection to other economies or where overland connectivity is limited are assumed to transport all of their traffic via submarine cables – as outlined in Chapter 1. Here satellite or radio is not an alternative due to inferior quality and latency as well as very limited capacities. These economies are Australia; Brunei Darussalam; Hong Kong, China; Indonesia; Japan; Korea; Malaysia; New Zealand; Papua New Guinea; the Philippines; Singapore; Chinese Taipei; Thailand and Viet Nam. For the following member economies other assumptions were made (refer to worksheet "Traffic Flows"):

Canada / Mexico / United States: Canada and Mexico are assumed to form **one traffic block with the United States** as overland connectivity should be widely available. Thus, traffic and capacity is totalled and treated as one large economy. As most data accessed via the internet is stored on servers in the United States, international bandwidth is only of limited importance to the functioning of the internet in the United States. Its connectivity originates from other economies connecting to the United States in order to make data available to their domestic customers, which is stored in the United States. Furthermore, trans-Atlantic routes are at least as important to the US as trans-Pacific routes, but are outside the scope of this model. **Thus, the model assumes only 4% of US internet relies on international bandwidth,** 1% for each international data hub Sydney, Tokyo, Hong Kong, China and Singapore. As the US is treated as one large economy with Canada and Mexico for the purposes of this model, these assumptions are made for this entire theoretical construct.

Chile / Peru: Chile and Peru will only partly rely on submarine cables in scope of the model, as significant parts of their internet traffic comes from other South American economies due to the common language and regional focus and therefore will be transported via overland cables. In addition, both will have at least indirect access to trans-Atlantic cable systems, allowing them to benefit from additional redundancy. **Thus, the model assumes 50% of traffic to be transported via submarine cable systems in scope of the model**.

China: Chinese operators have realised their dependence on the US and trans-Pacific submarine cable systems for international data connection and have subsequently established an alternative route via Russia to Frankfurt/Germany, where they peer with international operators. **Thus, 33% of Chinese internet traffic is assumed to be sourced using this alternative route and circumventing the submarine cables in scope of the model**.

Russia: Russian traffic will mostly originate in the European parts of Russia as these are the more developed regions and where most internet users live. In addition, Russian operators usually transport much of their domestic data to Europe. Thus, Russian reliance on submarine cables in the Asia-Pacific region will be marginal, **1% is assumed to be in scope of the model.**

Private networks traffic is usually characterized by corporate and government traffic. A good approximation can usually be found in trade flows and volumes. The model is based on APEC statistical trade data. All trade and thus traffic flows outside of the scope of this model are being ignored, such as US trade with Europe resulting in private networks traffic on trans-Atlantic submarine cables. For the island-like economies listed above, all private networks bandwidth is assumed to be relevant for the model.

Voice was modelled similarly to private networks traffic. However, the underlying data is taken from Telegeography statistics on voice volumes between different economies. Unavailable data was interpolated and assumed to be relevant to the same extent as available data. Again, the entire traffic for island-like economies was assumed to be relevant.

Total relevant traffic consisting of the sum of relevant internet, private networks and voice traffic was then matched with available capacity. Then cable disruptions were simulated by "switching off" one cable after another: As long as the capacity available to each member economy exceeded relevant traffic, it was assumed that no traffic would be lost in case of submarine cable disruptions.

When traffic demand exceeds available capacity supply, internet traffic is assumed to be lost first, followed by private networks traffic and finally voice. This assumption may be a simplification but follows basic economic rationale that the highest value traffic will be the last to be disrupted whereas lower value traffic (general internet) will be the first to be disrupted. The result of this section of the model is thus the loss in internet, private networks and voice traffic for each member economy.

A first major conclusion at this stage was that an outage of a single landing point or any single submarine cable will not lead to a loss in traffic. This shows that the **basic redundancy requirements in the region are being met** and that single occurrences will not affect economies beyond the direct costs of an outage.

Translation into costs (direct and indirect/economic costs)

The loss in traffic figures from the first part of the model were then translated into economic damage, direct and indirect. Whereas the calculation of direct costs, i.e. repair costs, is relatively straightforward, the calculation of economic damage, thus indirect costs, is more complicated and appropriate approximations were used. These depend on the economic sectors affected by the loss of the kind of traffic in question and the available alternatives. Thus, the effects were modelled per traffic type (in worksheet "costs").

Direct costs

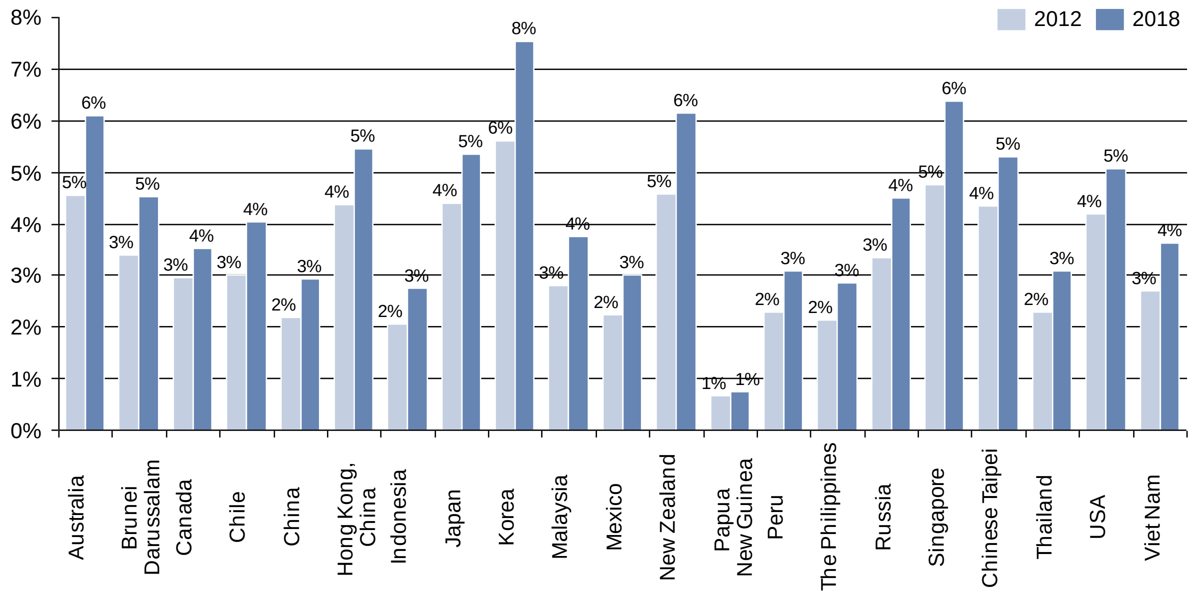
Direct costs of a submarine cable break are the **repair costs**. They are typically paid by the submarine cable owner. As the direct costs are almost negligible when compared to indirect, economic costs, they were subject to a straightforward, simplified calculation based on estimations following Detecon's expert knowledge.
The results are in line with press releases concerning affected submarine cables as well as with the replies to the survey. **Repair costs mainly arise from the sum of the cost of a repair vessel for getting to the affected cable, finding and repairing it plus the cost of the repair itself (material etc.)**. The duration of this exercise also determines the duration of the outage.

In order to provide an example, a hypothetical submarine cable disruption could entail the following direct costs and duration of outage:

Direct costs		
Ship	**Unit**	
Arrive at Cable	Days	2
Find Cable	Days	6
Repair Cable	Days	3
Return	Days	2
TOTAL	Days	13
Costs per day (USD)	USD	x
Repair costs (USD)	USD	y
Total direct costs (USD)	USD	13x+y
Average time to repair	Days	13
	Years	0.035
	Used	0.035
Number of submarine cables affected	#	1
Direct costs	USD	**e.g. 1,360,000.00**

Figure 15: Direct costs

When calculating the **indirect costs (economic impact)**, the proxy chosen for internet traffic is the percentage of GDP contributed by the internet economy corrected by an estimation of the proportion of domestic traffic. Since there was only data available for some APEC economies on the contribution of the internet economy to GDP, this was estimated for the remaining economies by using the ITU’s ICT Development Index. A trend analysis was performed for those economies where both the ICT Development Index and the contribution of the internet economy were available. For the remaining economies, the contribution of the internet economy was then interpolated based on the ICT Development Index. As there was no data available for Chinese Taipei, it was set equal to Japan as a comparatively developed economy in terms of ICT development (refer to worksheet “Economic Calcs”).



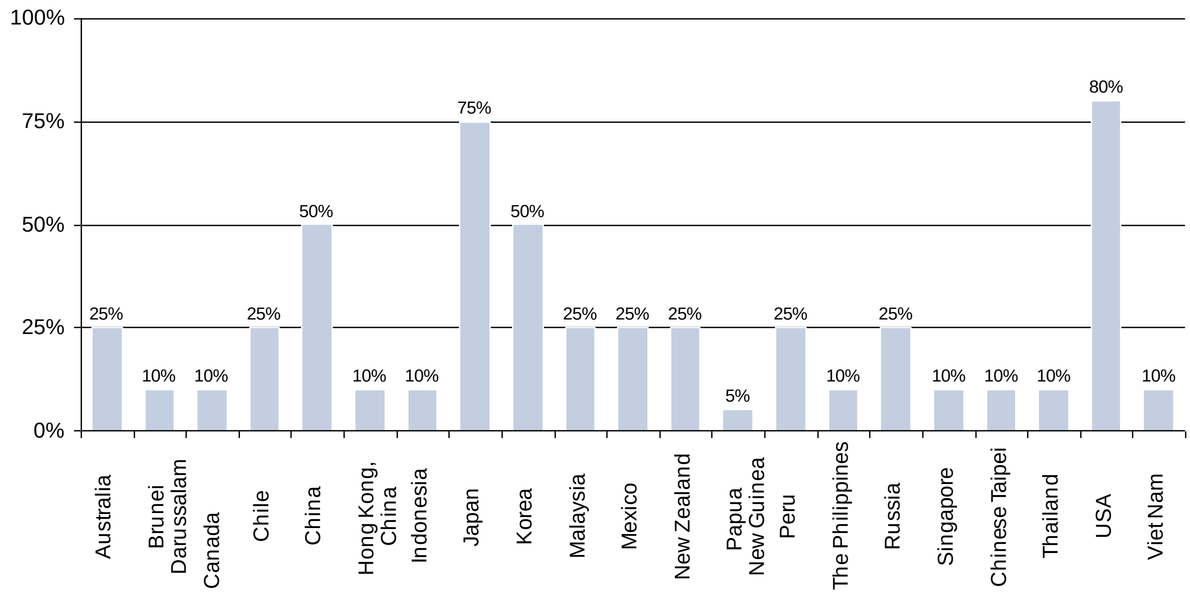
Source: Detecon

Figure 16: Contribution of the internet economy to GDP 2012 / 2018

Since the functioning of the domestic internet relies only partly on international bandwidth but significant proportions of data are stored on domestic servers, an estimation was made per **APEC economy regarding the reliance on international bandwidth**. Determining factors are the role of each economy's hubs in the global internet, common languages with other economies and the economies' overall size and bandwidth.

For example in the case of the US, the vast majority of internet data is stored nationally. For Japan, this will be similar, since Japanese internet users predominantly access domestic services due, for example, to language barriers. For Australia and New Zealand on the other hand, the common language shared with many other important internet economies translates into a far lower proportion of domestic internet.

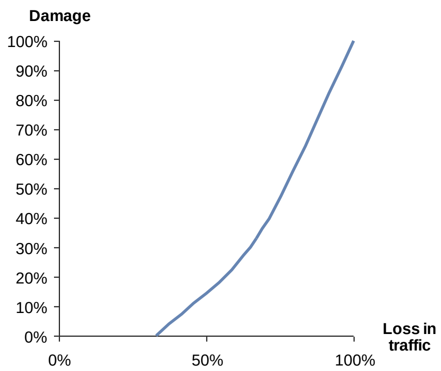
The assumptions per APEC member economy are shown in the figure below. It should be noted that this assumption assumes that connectivity for address servers is available which translate internet addresses as entered by the users into IP numbers. However, as the survey reply by Hong Kong, China shows, there has been improvement in this regard since the last significant submarine cable outage.



Source: Detecon

Figure 17: Proportion of internet traffic originating within economy

The **translation of the loss in traffic into economic damage** is done in a **three-step procedure**, taking into account the types of internet traffic, their distribution, and the fact that limited bandwidth will lead to congestion which in turn will lead to internet access being slowed down (refer to worksheet "Costs").



Source: Detecon

Figure 18: Damage to loss in traffic

Thus the model assumes that for up to one third of internet traffic lost, there will be no economic damage. This then increases to reach one third of maximum damage when two thirds of traffic are lost. Only if more than two thirds of traffic is lost, will the damage increase to reach 100% of maximum damage.

The thresholds were chosen to underline that the economic effect increases as the congestion becomes more severe and that there is no proportional relationship. In addition, internet providers need to make bandwidth available not only for daily traffic peaks but also for weekly and monthly peaks. With about one third of bandwidth lost little congestion will occur outside of these peaks. With two thirds of capacity lost, congestions will start to become significant at all times, affecting the economy.

Private networks traffic mainly consists of corporate and government bandwidth for connecting dependencies with each other and headquarters. The model is based on the simplification that this will mainly be driven by trade. Thus, the economic role is quantified by value added of data connectivity in trade to GDP: i.e. the contribution which connectivity makes to trade and thereby indirectly to GDP.

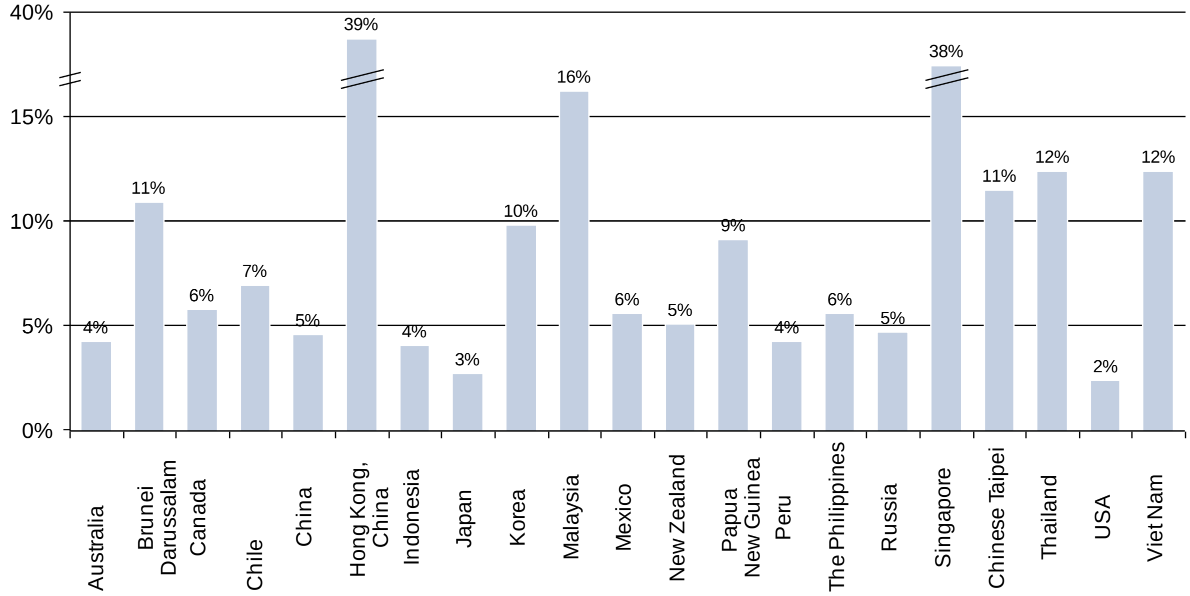
This, however, is a factor more complicated to estimate. From the statistical data available from APEC, trade was calculated as a percentage of GDP. As trading does not contribute its full value to GDP but only as the proportion of additional value added by the trading economy, trade as a percentage of GDP was corrected. The model assumes that this value add will differ across sectors (agriculture, industry, services).

Furthermore, the required number is not the **value add** of trade but **of international bandwidth to trade**. Due to the lack of specific data for trade, aggregate data for each economy was used for trade, meaning that there is an implicit assumption that the composition of the overall economy reflects its trade composition.

For industry and services a contribution (of international bandwidth to trade) of 10% was assumed for international bandwidth, for agriculture this was assumed to be 3%.
Clearly, the contribution to data bandwidth by agriculture is far lower as production will be unaffected without any data connectivity – however, trading at optimal prices will become more difficult.

Concerning industry and services, 10% is a rough assumption of the value added to trade dependent on international bandwidth. Certainly, complicated controlling and steering processes are heavily affected by a lack of connectivity to headquarters and need to be pursued using alternative technologies such as telephony. For services, the effect is more clear but no simpler to estimate. Financial services in particular can be heavily affected by a lack of connectivity when they are cut off from the main international trading places in Europe, the US or Asia. These calculations can be found in the worksheet “Economic data”.

The maximum damage is the equivalent in percent of GDP in US dollars. The model assumes the damage to occur proportionally to loss in traffic.



Source: Detecon

Figure 19: Value added by data connectivity in trade to GDP

Concerning **voice traffic**, the model assumes simple re-routing via satellite, as for the low-bandwidth services sufficient satellite capacity will be available and voice traffic is generally considered valuable enough to do this expensive re-routing. The model is based on an additional cost of USD 3000 per Mbps per month for satellite traffic – voice re-routing costs are calculated based on overall voice bandwidth loss and satellite costs.

An important factor for determining economic costs is the duration of an outage. The model calculates it using a formula that takes into account the experience that single cable outages can usually be repaired in about 16 days if the damage is in coastal waters. This allows 10 days to mobilize and ship to the outage, 3 days for finding the cable and another 3 days for the actual repair. As repair ship availability is limited, the model assumes that for multiple cable outages in excess of two, the overall repair time will increase by 8 days. As these are only rough assumptions and not suitable for all modelling requirements, the duration can also be changed manually in the worksheet “Cockpit”.

Model functionality and limitations

The model provides a view on each APEC member economy, its bandwidth and capacity for both the years 2012 and 2018. It allows the choice of individual cables, landing stations and “critical areas” (with a variety of cables passing by) and the modelling of the effects of outages at each of these (“switching off”). The model calculates the outage duration depending on the number of submarine cables affected, but allows for the manual input of other durations in order to provide for a thorough scenario analysis.

As in any model, there are also **limitations** to its functionality:

1. It is not possible to take parts of submarine cables out of service, but only has the options for the cable to fully function or to be completely offline. This does not reflect reality, where parts of a submarine cable may be out of service, while others are fully operational, but is unavoidable in order to keep the model manageable both for its users and programmers.
2. In order to control the model’s complexity, no routing has been incorporated. This means that even though traffic is mostly heading for the US (or Europe in some instances), this is not shown in the model result. For example, an outage in the Strait of Luzon may leave sufficient capacity available for some South-East Asian economies – which would be the result shown by the model - but results in a considerable bottleneck in capacity to the US, which would be an actual problem in reality. This insight needs to be provided in the analysis and interpretation of the results.
3. Another limitation is the rough estimation of the economic variables. The one used for trade / private networks bandwidth is of particularly limited meaning. Nevertheless, the variables provide a way of quantifying the effects and show the differences in dependency on international data connectivity between the different member economies.

The model is based on **various assumptions, most of which can be altered in the worksheet “Cockpit”.** This allows the user to test the sensitivity to individual assumptions but also to test the effects of more conservative or aggressive assumptions. Furthermore, the handling via a single cockpit allows use of the model without diving into its calculations. It provides an easy-to-handle interface.

MODEL RESULTS

The **results** of the model can be grouped into three categories:

1. There is sufficient redundancy and resilience in the APEC footprint now and also for the traffic demands towards the end of the decade given the number of new submarine cables and the potential capacity of existing cable systems. Every member economy is connected using various landing points (at least two), which also provides redundancy in terms of landing points and in more endangered coastal waters.
2. There are some critical areas, where the establishment of additional geographic diversity may be helpful, mostly in the Strait of Luzon, where no alternative overland route is available. Furthermore, the deployment of further, already planned cables will continue to provide additional geographic diversity and will reduce the effect of multiple outages in coming years. However, the model also outlines the economic importance of international connectivity as a whole and that significant economic costs are associated with a loss in traffic. International connectivity remains a relevant issue and submarine cables carrying most of that traffic need to be protected.
3. The economic impact of a loss in submarine cable connectivity for individual APEC economies varies depending on the respective size of the (international) internet economy and the network effects. For example, following the model, a fault in all landing points in Australia would entail direct costs (for cable repair) of US$ 2.2 million and indirect economics cost of US$ 3,169 million mostly due to the loss of 100% of international internet traffic. It should be noted that the loss of internet connection in Australia would also cut off the internet connection in Papua New Guinea. For a similar case in Korea, the indirect economic costs would be around US$ 1,230 million. But for a similar case in Canada, the economic costs would be zero, as there is alternative overland connectivity available to the US. In general one can infer that the economic impact of submarine cable disruptions would be relatively much higher in APEC island member economies as they lack alternatives to submarine cables for international data connectivity.

For each APEC member economy this would mean:

Australia will potentially have improved geographic diversity in the coming years due to a number of proposed additional submarine cables. This will reduce both the effects of submarine cable faults and possibly also the price level domestic users have to pay for bandwidth. It will further enhance the internet's contribution to GDP.

Brunei is well connected given its size with two landing stations, three submarine cable systems and the possibility of overland connectivity to Malaysia.

Canada mainly relies on the United States for international connectivity, which is served via overland cables. Thus, Canada's reliance on submarine cables is limited.

Chile has both accesses to the US via submarine cables as well as redundancy by Atlantic cables to South America via overland connections. In addition, a significant proportion of traffic will be intra-South-American. Furthermore, it possesses two separate landing stations on its coast and three submarine cable systems, providing basic redundancy on its own coast as well.

China has reduced its reliance on submarine cables by the establishment of a direct overland connection to Europe via Russia. Furthermore, it is linked via an overland connection to Hong Kong, China and its multitude of submarine cable systems and has its own access to seven submarine cable systems, with three further ones planned to land at ten landing stations. It is thus well covered even accounting for its exploding bandwidth growth.

Hong Kong, China: As a major internet (and trade) hub, submarine cable connectivity is of special economic importance. However, this means traffic outages are likely to have a severe impact on other South-East Asian economies as well. Overall connectivity is thus very large and important not only to Hong Kong, China itself but also to the region in general.

Indonesia: Due to its geographic position and the routing of international traffic and most submarine cables, Indonesia heavily relies on Singapore as a hub for international connectivity.

Japan: The earthquake in March 2011 has shown that Japan's submarine cable infrastructure is vulnerable to such events but sufficiently protected by various measures to control major effects on traffic. However, with Tokyo as a major international traffic hub, Japan's international connectivity is also important to other economies in the region.

Korea: Even though not an island, Korea's reliance on submarine cables is island-like due to the lack of availability of an overland route through North Korea. It is one of the largest bandwidth users in the region but has access to a geographically diverse network. It has access to five submarine cables with four additional ones being planned landing at a total of three locations.

Malaysia can easily establish overland connectivity to Singapore, one of the main internet hubs in the region. Nevertheless, the model assumes bandwidth demand is solely covered by submarine cable systems. Malaysia's positioning over two islands has been ignored in the model, due to the exclusion of domestic data distribution. Malaysia has access to nine submarine cable systems with two more planned for landing at four geographically different points. In addition landing points in Brunei Darussalam can be utilized.

Mexico mainly relies on the United States for international connectivity which is served via overland cables. Thus, its reliance on submarine cables is limited.

New Zealand has only access to one submarine cable in scope today (also to a smaller one linking it to Australia), which however is built in such a way that it provides redundancy as if it were two separate cables (ring structure). In addition, two more submarine cable systems are planned. These cables land at three different landing points. Again, domestic connectivity was ignored. Given New Zealand's two island geography and that its mature economy is highly dependent on submarine cable capacity, it remains a concern whether the submarine cable connectivity is sufficient to provide full redundancy under extreme circumstances. New Zealand may be an exception where the market fails to provide the optimal solution due to the high costs of laying submarine cables to such a remote location and the limited connectivity required by relatively few people.

Papua New Guinea relies on submarine cables like an island. The deployment of connectivity to Guam - where various submarine cable systems land - provides an alternative route to the one to Australia. With two landing stations and two submarine cable systems, connectivity is redundant especially when taking into account Papua New Guinea's very low demand for bandwidth.

Peru, similarly to Chile, has access to the US via submarine cables as well as redundancies via Atlantic cables to South America via overland connections. In addition, a significant proportion of traffic will be intra-South-American. Furthermore, Peru possesses two separate landing stations on its coast and three submarine cable systems, providing basic redundancy on its own coast as well.

The Philippines: Due to many submarine cables landing on the Philippines while passing by, international capacity far exceeds domestic demand. There are six different landing points for submarine cables, all but one on the western coast. This also prevents the Philippines from being able to **offer a fully redundant overland alternative to cables passing through the Strait of Luzon,** one of the bottlenecks in the region. This could be a significant revenue source for Filipino operators in a moderately liberal telecommunications market, a topic not covered in the analysis of this report.

Russian traffic mostly originates in its European part or is transported there via overland cables. Its reliance on Pacific submarine cables is thus limited. Traffic is mainly destined to European internet hubs connected overland or via Baltic submarine cable systems.

Singapore, the other significant data hub in South East Asia besides Hong Kong, China is connected by a multitude of submarine cables. Thus, capacity is not only serving domestic needs. No threat or area needing improvement is identified by the model, although the situation in the Strait of Malacca should be closely monitored.

Chinese Taipei is another of the few economies in scope where further submarine cables could decrease the effects of large submarine cable outages. The reliance on cables passing through the Strait of Luzon is high today but alternative cables towards China are being planned. However, an additional cable on this side may be helpful to establish full redundancy and to avoid loss of any traffic towards the end of the decade after outages in the Strait of Luzon.

Thailand has access to submarine cables both on its western as well as on its eastern coast, even though some are of limited capacity. In addition, overland capacity to Singapore is an option, even though not assumed to carry international bandwidth in the model. Thailand thus has sufficient redundant cables. Thailand could be able to **offer an overland alternative to cables passing through the Strait of Malacca,** one of the bottlenecks in the region. This could be a significant revenue source for Thai operators provided a moderately liberal telecommunications market, a topic not covered in the analysis of this report.

US: For the US, submarine cables and international connectivity are more a matter of other economies accessing US data than serving domestic data demands. Nevertheless, this does not make the US independent of international connectivity, as there are economic consequences both directly to its telecommunications and IT industry and indirectly for example for financial services which are heavily dependent on real-time data connections. Probably more important for the US are trans-Atlantic cables where the market is characterized by more than sufficient route redundancy and large overcapacities. These are the connections to Europe, the Middle East and Africa with Europe increasingly becoming an equally important data hub. Landing points on the west coast are also geographically diverse and numerous (19).

Viet Nam has access to three submarine cable systems in scope and one more planned. These cables land at two landing stations. Redundancy could thus be improved, especially with respect to landing stations as overland connections are probably not an option.

HYPOTHETICAL CASES

In order to outline the functionality of the model, two hypothetical cases are described:

1. **Disruption of the Landing Point "Perth" in Australia in 2012**: In the worksheet "Cockpit" under "Fault in" select "Landing Points". Then untick the box for "Australia – Perth". Choose 2012 under "Year" and "Length of outage" "as calculated". The model then reduces the overall capacity for Australia by the amount exclusively supplied by submarine cables to Australia at this landing point, i.e. if a cable has another landing point in Australia, this capacity will still be available. In this case the available capacity of Australia is reduced from 4,300 Gbps to 3,800 Gbps. As Australia's current overall traffic is below 1,000 Gbps, sufficient redundant capacities are available even after a disruption at Perth. Traffic usually routed via the west coast cable can be diverted to the east coast cables. Hence, there will be no economic damage, but only the direct damage for the cable repair of about USD 400,000.

2. **Disruption in the Strait of Luzon in 2012**: In the worksheet "Cockpit" under "Fault in" select "Critical Areas". Then untick the box for "Strait of Luzon". Choose 2012 under "Year" and "Length of outage" "as calculated". The model now switches off all cables passing through the Strait of Luzon. Available capacity is thus reduced for every member economy. As various cables are affected, the calculated time to repair is 64 days. Traffic is completely lost in Korea, Chinese Taipei and partly lost in China. This is converted into economic effects making up indirect costs. It should be noted though, that this complicated scenario goes beyond the limits of the model. In reality Korea would be able to widely rely on the still functioning legs of its cables towards Japan and the US and damage would be far lower than calculated in the model. For Chinese Taipei, however, alternative routes are not so widely available and it is likely to be severely affected by such an outage, as indicated by the model. In addition, further economies would be affected as some South-East Asian economies would lose their entire connectivity with the US. Even though sufficient bandwidth would still be available, there would be effects caused by the lack of connectivity to the world's main internet hubs.

4. ANALYSIS OF CURRENT PROTECTION AND IMPACT MITIGATION MEASURES

DEALING WITH GLOBAL PRIVATE PROPERTY THAT HAS DOMESTIC PUBLIC INTEREST

Do the cable operators provide the necessary supply and resilience?

When the current protection and impact mitigation measures are examined and then new and possibly more effective ones are recommended, **member economies might wonder to what degree their dedication to the deployment, management and repair of submarine cables and to their protection and the mitigation of disruptions is necessary.** Why should they review existing measures and propose new ones when there are the cable operators which have vital, own interests in protecting the cables and keep outages as short as possible and who can keep things under control?

General perspective

The following can be concluded from **general economic theory**: The basic principle in a market oriented economy is to leave the satisfaction of human needs with scarce resources to the voluntary initiative of (private) suppliers which are attracted by a demand and are willing to satisfy it in return for compensation. Both will form a market and provided that there is equilibrium of power and economic freedom resources will be exchanged in the most efficient way regarding price and quality. Therefore, interference by the government should not be an end in itself but be limited to those cases where a superior purpose, which cannot be provided by the market, is to be served or the named equilibrium is missing.

Sure enough, the permanent re-balancing between rising demand for international bandwidth and the respective supply through new or upgraded submarine infrastructure is a perfect showcase for the basic working mechanisms of a free market economy. As long as satisfying the demand promises sufficiently high profits, there will be someone seeking to do so. And this prerequisite is generally given in the business we are looking at: the addition of new cables documents that the business is sufficiently financially attractive. Even if the initial roll-out costs of submarine cables are high, in most cases benefits start to kick in soon after the cables have been deployed. In fact, incremental upgrade costs are low, while margins and cash flow potentials may be large.

For example, Southern Cross - which is 40 per cent owned by SingTel - pays a regular, publicly announced dividend. In 2010, total dividends were around US$90 million and in the two previous years they ranged between US$125million and US$140 million - for an initial investment of US$1.3 billion in 2001[53]. The example shows that an investment into submarine cables is generally economically attractive.

[53] Asia ex-Japan submarine cables worth US$11-21 billion, The Business Times Singapore, 2011

The market development and the ongoing deployment of submarine cable systems show very well that these basic principles of a market economy are well suited to fulfil the demand for international bandwidth. Parties on both sides of the market are typically equally strong so that the mentioned, necessary equilibrium in the market yielding an efficient balance of price and quality is secured. **Government intervention and activity are therefore generally not needed to ensure satisfaction of the basic demand for international connectivity as this is sufficiently well delivered by the market.**

Overly strong intervention could even hamper investments in additional cables. This would be dangerous as the deployment of a dense and geographically diverse network of submarine cables is the most effective way of preventing cable disruptions from having a negative impact on the data connectivity of a member economy as it allows for rerouting of traffic. The ongoing deployment of additional cables by the operators is an important step towards more network resilience.

However, there may be single regions or even economies whose connection to submarine cables is not sufficiently ensured through private initiative due to a lack of economic viability in the face of high initial investments. Public incentives or investments may then be necessary to ensure social and economic development.

Moreover, these functional principles of a market economy - that demand attracts supply and human needs are met through the prospect of profits to be made, generating overall welfare for everyone by the “invisible hands” of the market - generally ensure that the **necessary number of redundant and alternative routes and the protection of submarine cables are also provided**.
Submarine cable operators and telco operators, as well as their customers and shareholders, have a natural incentive to maintain an uninterrupted connection and to protect the cables and mitigate impacts, in line with the entire economies they connect, as this is the foundation of their business.
However, resilience can never be guaranteed by either government or industry alone and cooperation is needed and advised wherever possible.

Results for the current situation in the APEC region

Furthermore, in the concrete case and the actual situation in the APEC region the cable operators deliver the necessary supply of data connectivity and have established a generally sufficiently resilient and redundant network. **The economic impact model, introduced in Chapter 3, the accompanying analysis and all other analysis done in this study have shown that there is in general sufficient redundancy and resilience in the APEC region.** An outage of a single landing point or any single submarine cable will not lead to a loss in traffic, which shows that the basic redundancy requirements in the region are being met and that single occurrences will not affect economies beyond the direct costs of an outage.

Hence, strong intervention by member economies into the submarine cable business is not necessary to secure basic supply and resilience through a sufficiently redundant network.

Public dedication to submarine cable infrastructure

However, member economies may play a role in helping to secure the systems. **There is a certain need and reason for member economies to get involved in the protection of submarine cables and the mitigation of incidents.** What then are the additional superior economic purposes related to the protection of submarine cables, which cannot be served by the market[54] and should therefore be addressed by member economies?

General reasons for public dedication:

1. From an economic perspective, submarine cable operators as private entrepreneurs have by nature **a limited incentive to take the overall stability and performance of the whole data network connecting an entire economy, including even multiple submarine cables of competitors, into account**.

   For the same reason, their level of willingness to invest in order to prevent cable disruptions is limited to the sum that they would individually lose in the event of a disruption, despite existing cooperation.

   As a result, the cable operators' plans may neglect the mitigation of those impacts of a cable disruption which only strike third parties, as they have little financial incentive not to do so. From the perspective of economic theory, this is an external cost to the operator which he does not have to bear. Only the direct costs for the repair of the submarine cable and the lost revenues during an outage are to be carried by the operator. In addition, the efforts taken by cable operators to protect sea cables and mitigate impacts may vary significantly from operator to operator.

   In contrast, an entire economy and the government regulating it have an incentive to secure overall network stability, and not just a single cable, and to take into account the consequential losses a cable disruption would mean for the overall economy. As shown in Chapter 3, the economic impact for an entire economy in terms of indirect costs can be extraordinarily high in certain disruption cases. It should provides a great incentive for member economies to prevent this from happening.

   In summary, submarine cable systems are too important and potential consequences too grave for the economic and social wellbeing of member economies for them to refrain entirely from their protection and impact mitigation. The fact that several member economies classify submarine cables as critical infrastructure reflects this thought. In this sense submarine cables are very similar to other critical industries that are either vital, like the supply of electricity, water and fuels, or bear high risks, like the chemical or the nuclear power industry. Here it is also common sense that a certain public dedication is required for their protection and impact mitigation.

2. A second reason why the involvement of member economies in the improvement of submarine cable protection and impact mitigation measures is necessary is that **the**

[54] There are surely such purposes outside of the mere economic agenda which are typically not sufficiently addressed by market participants, especially social and ecological issues. But these so-called "externalities", where the actions of an individual have impacts on others for which they do not pay, or for which they are not compensated and where markets will not work well, shall not be part of our considerations.

private submarine cable industry lacks to some extent the instruments needed to effectively protect submarine cables, especially against man-made dangers. Basic measures which are needed to protect cables against these hazards require interaction with third parties such as fishermen, commercial vessels and telco operators. Only the member economies themselves have the powers and the legitimacy to impose legally binding, general regulations on these groups in the name of protecting facilities of overriding economic importance. Only member economies can and should enact meaningful and modern domestic law to deal with cable faults caused wilfully or through culpable negligence by third parties. They should enact and enforce effective criminal law and provide for access to civil remedies in court, which will deter harmful conduct and allow damages to be recovered from those responsible.

In addition, where a framework has to be set up that spans more than one operator to reach some uniformity and standardization in the application of certain rules, a superior level of coordination across member economies may provide additional effectiveness and legitimacy.

3. From a **general political perspective,** communities expect their governments to engage in issues that impact the economy's economic welfare. As shown above, submarine cables are very significant for the economic prosperity and social wellbeing of overall economies, as well as for citizens' private endeavours and even for their security and safety.

4. As shown in Chapter 2, member economies and cable operators may have varying views as to the availability of cable repair vessels. This could require a rebalancing, as the overall economic objective of the member economies must be to strive for the highest availability and shortest possible repair times.

Conclusion

In summary, the basic balance of market powers works sufficiently well to prevent market failures as there are equally strong parties on the supply (submarine cable operators) and the demand side (telco operators, big enterprises). **Connectivity and basic reliance and redundancy are therefore generally provided by the market**. **Competition already contributes to increased network resilience** as the deployment of a dense and geographically diverse network of submarine cables is the most effective way of preventing cable disruptions from having a negative impact on the data connectivity of a member economy as it allows for rerouting of traffic.

Hence, member economies do not have get intensively involved. This is only different for certain choke points and special cases as explained in more detail throughout this study, especially in Chapter 2 where special attention should be paid to.

However, as shown above, there are certain reasons why member economies should still take the issue of submarine cable protection and impact mitigation seriously. This should be done in close cooperation with the cable industry which is in the best position to identify weaknesses and critical points.

Man-made hazards in particular can be reduced considerably with the right instruments, and provisions for natural disasters have to be made. Therefore, a common comprehensive approach for submarine cable protection and impact mitigation is needed. Member economies should take the topic seriously.

The overall minimum-approach should be to build up the capacities to monitor the situation, obtain as much information about the status as possible, and prevent undesirable developments as soon as possible. In addition the provision of basic protection measures against the common, likely hazards on the one hand, and the less likely but especially devastating ones on the other, must be made. It is strongly advised that a dedicated and coherent common approach of APEC member economies is set up to achieve this and to enhance cooperation in between the member economies and with the cable operators.

Where measures aiming at the protection of submarine cables and impact mitigation can be reached using agreements and in cooperation with the cable owners and operators this is preferable to imposing any obligations. Legal obligations may even hamper the operators' efforts and initiative in protecting the cables and thereby have an adverse effect on network resilience. Hence, if legal instruments are considered as a way of adopting cable protection measures, their effects should be closely assessed and the alternative of reaching agreement in cooperation with the operators should always be borne in mind.

DIFFICULTIES OF APPLYING DOMESTIC POLICIES TO GLOBALIZED INFRASTRUCTURES

A difficulty in establishing domestic standards concerning the protection of submarine cables and impact mitigation is that the **area of legal application and enforcement is limited to the member's own domestic, sovereign territory. Submarine cables are by nature trans-border facilities**, have landing points in multiple jurisdictions and run in large parts through High Seas (international waters), as defined by Art. 86 sqq. UNCLOS[55] (10th December 1982). These are not subject to the sovereignty of member economies.

Any single point on the submarine cable network is only as secure as that of its extremities and cable operation depends on the viability of its entire length - a breakage at one point will have impact on the cable network as a whole[56].

When analysing the existing measures for the protection of submarine cables and impact mitigation measures or when conceiving any recommended future ones, one has to be bear in mind the need to address the entire cable system, as far as possible, while also recognizing the legal and factual restrictions this approach faces. Existing and new measures are useless if they cannot be enforced. Enforceability therefore always has to be considered[57].

This is another reason why cooperation between member economies and cable operators is necessary and should always be included in every cable protection strategy.

[55] Any reference made to the UNCLOS in combination with any member economy is conditioned by the treaty's due ratification by the member economy and the status of a full State Party.
[56] Legislative Practices and Points of Contact, Cyber security Policy and Asia Pacific Section, 2012, page 3
[57] A detailed assessment of complex legal questions of public international law is not inside the scope of this study.

A purely top-down government approach is not advisable anyway, but if it is not enforceable, then it would become less effective.

In summary, several possible policy approaches could be the following:

1. A **territorial approach** is viable, applying domestic laws to those parts of submarine cables that enter the **territorial sea of a member economy spanning 12 nautical miles from its coast line**, as defined by Art. 2 sqq. UNCLOS. Here, full sovereignty applies and all facilities entering these waters may be subjected to any legal measures which the member economy deems appropriate and which are viable under domestic law. This includes especially submarine cable landing stations which could be subject to measures aiming at protection and impact mitigation.

   Although this approach would not cover those parts of submarine cable systems running through high seas, applying rules to the parts in the territorial seas may be sufficiently effective for specific cables, if all affected member economies coordinate their measures. So rather than leaving the initiative for taking appropriate measures with every single member economy, a common and aligned approach by all member economies in cooperation with the cable industry is needed to ensure effective cable protection.

2. If member economies want to extend the effectiveness of their laws to areas outside their sovereign territory, a **personal approach** is possible, applying domestic laws dealing with submarine cable protection to persons subject to its jurisdiction. Then the important question would be who exactly falls under the jurisdiction of a member economy. In the case of an economy-wide provision by a member economy punishing an offender who wilfully or negligently damages a submarine cable there are four widely recognized bases of jurisdiction under customary international law: territoriality, nationality, protective principle, and universal jurisdiction.[58] Territoriality means what was explained above under point 1 and is restricted to the sovereign territory. Nationality, protective principle and universal jurisdiction however tie in with individuals and may also be applied outside the sovereign territory.

   The '**nationality principle'** relates to the exercise of jurisdiction by a government over ships flying its flag or crew of its nationality onboard a ship flying another flag. In fact, Art 113 UNCLOS requires all state parties to adopt such rules. In the same way and as far as legally viable, the member economies could adopt similar laws on other measures aiming at the protection of submarine cables, which would apply to persons subject to its jurisdiction and to ships under its own flag.

   The **protective principle** allows governments to exercise jurisdiction over crimes affecting domestic security. The most extensive approach would be universal jurisdiction which however is difficult to argue.

   In summary, there are legal means to provide a stronger protection of submarine cable against individual conduct in particular. These should be discussed, more closely researched, and applied as far as possible. It is advisable that the adoption of respective measures are coordinated between all member economies, and that an aligned approach is chosen in order to reach the highest possible effectiveness.

[58] Law and Policy for International Submarine Cables in the Asia-Pacific Region, Yoshinobu Takei, 2011

3. One major instrument to effectively enact legislation about the protection of submarine cables is **international law**. The most important treaty in this regard is UNCLOS, which will be analyzed in more detail below. UNCLOS is already an adequate and very helpful instrument that to some extent led to the growth of the modern international submarine networks. It is **important that all member economies which are State Parties comply with the requirements of UNCLOS**, enact the required domestic cable protection legislation, and respect its provisions in the EEZ and upon the continental shelf, where it limits domestic laws that restrict the freedom to lay and repair international submarine cables.

   However, in the long run APEC and its member economies could aspire to further develop and enhance the international law regime on submarine cables in order to improve their level of recognition and protection. For example, this could be achieved through an amendment to UNCLOS, to the more specific Convention of 1884[59], or the creation of a new specific treaty. A regional or APEC internal treaty would probably be a quicker alternative that could be a first step towards enhancing the protection of submarine cable systems and impact mitigation measures with a binding international legal instrument. This instrument could impose additional requirements on State Parties to enact domestic laws aimed at protecting submarine cables or mitigating impacts and could even aim to reach self-executing rules of international law directly addressing individuals like fishermen.

There is already increased international awareness on the issue of cable protection. On 7th December 2010 the **UN General Assembly passed its annual omnibus resolution** on oceans and law of the sea which, for the first time, contained two paragraphs on submarine cables[60]. **The Resolution called upon States to take measures to protect submarine cables which it described as "critical communications infrastructure" and as "vitally important to the global economy and the national security of all States"**. With the ever-increasing importance of global electronic connectivity the time may soon have come when an international treaty increasing the level of protection of submarine cables is viable.

In conclusion, the desired degree of enforceability in cable protection measures can be achieved in different ways. However, a coordinated and common response from member economies and cable operators is the best way forward and essential for protecting submarine cable systems effectively and mitigating the impacts of damage to them.

DIFFERENT LEVEL OF AWARENESS AND REGULATORY FRAMEWORK

So far, such a common, aligned approach by all member economies is missing. The **level of awareness for the overall topic can be described as quite imbalanced across the APEC member economies**. This includes awareness of the economic, social, cultural and public/security related importance of an uninterrupted data connection and of the major role that submarine cable systems have. The same imbalance, in consequence, applies to the

[59] Compare Law and Policy for International Submarine Cables in the Asia-Pacific Region, Yoshinobu Takei, 2011

[60] Guard the submarine cables that link us all, Tara Davenport, 2010

measures which member economies have taken so far in order to improve cable protection or ensure impact mitigation.

Questionnaire by the Australian government after APEC TEL 39 in 2009

According to the available data from the answers to a questionnaire which was prepared by the Australian government after the APEC TEL 39 meeting in 2009 and sent to all APEC member economies, eight economies answered (Australia; Chinese Taipei; Hong Kong, China; Korea; Malaysia; New Zealand; Singapore and Thailand) and the following is a summary of the answers[61]:

- Six economies (Australia; Korea; Malaysia; New Zealand; Singapore and Thailand) indicated that they are a State Party to UNCLOS[62].
- Four economies (Australia; Chinese Taipei; Hong Kong, China and New Zealand) have enacted legislation that specifically deals with submarine cables, whereas the other economies' measures are based on general legislation (e.g. Telecommunications Act).
- Six economies (Australia; Hong Kong, China; Korea; Malaysia; Singapore and Thailand) require application for and grant of permits, permissions, authorization or licenses ("permissions") prior to the installation of submarine cable systems in territorial waters and for some even in the Exclusive Economic Zone (EEZ).
- Five economies (Hong Kong, China; Korea; Malaysia; Singapore and Thailand) require an application for and granting of permission prior to the repair or maintenance of submarine cable systems in territorial waters and for some even in the EEZ.
- Five economies (Australia; Hong Kong, China; Korea; New Zealand and Singapore) have established that the intentional or negligent damaging of submarine cables is an offence. Chinese Taipei is intending to do so.
- Five economies (Australia; Chinese Taipei; Hong Kong, China; New Zealand and Singapore) have established or could establish submarine cable protection or no-anchoring and fishing zones.
- Four economies (Hong Kong, China; Malaysia; New Zealand and Singapore) have mapping obligations and display submarine cable systems and/or the protection zones on nautical charts.
- Three economies (Hong Kong, China; Korea and Singapore) have other kinds of measures in place aimed at the protection of submarine cables and especially exercises in countering terrorism, piracy and illegal anchoring by security forces and military.

New questionnaire for the purpose of the present study in 2012

For the performance of the present study a new, comprehensive questionnaire was composed in order to collect additional information on the overall topic from the public authorities of member economies[63]. It was sent to the responsible authorities via their APEC contact points.

[61] Legislative Practices and Points of Contact, Cyber security Policy and Asia Pacific Section, 2012, page 7
[62] See below for detailed information about UNCLOS and the current ratification status among APEC economies
[63] See Annex

Of the 21 member economies, 8 answered the questionnaire (Australia; Chinese Taipei; Korea; Hong Kong, China; Japan; New Zealand; Papua New Guinea and Singapore). Their answers show a picture similar to that of the previous questionnaire:

- 7 economies (Australia; Korea; Hong Kong, China (as part of China); Japan; New Zealand; Papua New Guinea and Singapore) indicated that they are a full State Party to UNCLOS:

    - **Hong Kong, China** is not a State Party itself but states that it deems itself to be bound by the treaty as a part of The People's Republic of China, which in turn is a State Party to UNCLOS. Hence, 6 members are legally bound by UNCLOS.
    - **Chinese Taipei** is neither a member of the United Nations nor a State Party to UNCLOS, but it states that it has enacted legislation according to the relevant parts of UNCLOS.

- 7 economies (Australia; Chinese Taipei; Korea; Hong Kong, China; New Zealand; Papua New Guinea and Singapore) have enacted legislation that specifically deals with submarine cables and transpose the provisions in UNCLOS regarding submarine cables (especially establishing criminal offences for the intentional or negligent damaging of submarine cables) into domestic law:

    - **Australia**: Schedule 3A of the Telecommunications Act 1997 introduced in 2005 establishes a regulatory regime under which submarine cables are installed and protected in Australian waters and gives the ACMA the power to declare protection zones over submarine cables. The Submarine Cables and Pipelines Protection Act 1963 also provides for the protection of submarine cables by implementing Articles 113 to 115 of UNCLOS.
    - **Chinese Taipei**: promulgated the"Law on the Exclusive Economic Zone and the Continental Shelf" and the "Regulations Permitting Delineation of Course for Laying, Maintaining, or Modifying Submarine Cables or Pipelines on the Continental Shelf" according to the related provisions of UNCLOS.
    - **Korea**: Article 79 of the Telecommunications Business Act prescribes protection of telecommunications equipment and facilities
    - **Hong Kong, China**: has legislation in place to protect submarine cables such as the Submarine Telegraph Ordinance (Chapter 497 of the Laws of HKC) which is based on the Convention for the Protection of Submarine Telegraph Cables.
    - **New Zealand:** has enacted the Submarine Cable and Pipelines Protection Act 1996, and the Submarine Cables and Pipelines Protection Order 2009
    - **Papua New Guinea:** The legislation in place that implements Articles 79 and Articles 113 -115 to a certain extent and was adopted post-independence is the "Submarine Cables and Pipeline Protection Act (Adopted)". However, its applicability to Articles 113 -115 is questionable as it refers to the Convention of the High Seas of 1958 and not to the UNCLOS of 1986.
    - **Singapore:** is in the process of implementing Articles 113 to 115. Submarine cable systems in Singapore are protected under sections Section 49(1) of the Telecommunications Act, Sections 46 (8) to (11) of the Maritime and Port Authority of Singapore Act, and Regulation 54 of the Maritime and Port Authority Regulations.

- In addition to the provisions of the member economies transposing the contents of UNCLOS into domestic law, 6 member economies (Australia; Chinese Taipei; Korea; Hong Kong, China; New Zealand; Singapore) have taken additional measures:
    - **Australia**: see above
    - **Chinese Taipei**: 1. Duty to obtain permits to survey and install a submarine cable or at least notification requirements for operators on cable setup, 2. prohibition for ships to enter or anchor in certain areas (protection zones), 3. monitoring or supervision of cable operation, 4. duty to obtain permits to repair a submarine cable, 5. allocation procedures to secure the availability and most efficient distribution of repair vessels, 6. monitoring or supervision of cable repair processes, 7. regulation and optimization of rerouting patterns in case of cable disruptions, 8. cable redundancy setup plans via incentives, PPP or public funding, 9. a ministry has established a database for submarine cable systems
    - **Korea:** The Korea Communications Commission may designate a submarine cable zone upon receipt of an application.
    - **Hong Kong, China**: see above
    - **New Zealand: C**able protection zones mandating the prohibition of activities in areas around submarine cables, such as fishing and anchoring, to mitigate potential damage through the Submarine Cables and Pipeline Protection Act 1996, and the Submarine Cables and Pipeline Protection Order 2009**.**
    - **Singapore**: has safeguarded designated landing sites and sea corridors for the landing of submarine cables. Infocomm Development Authority of Singapore (IDA) is the lead agency for facilitating the deployment of submarine cable systems into Singapore. IDA provides guidance to interested parties and facilitates the process of applying for the necessary permits from various authorities.

STATUS OF INTERNATIONAL LAW

UNCLOS

The most important instrument in international law for the protection of submarine cable systems is the **"The United Nations Convention on the Law of the Sea" from 10th December 1982 (UNCLOS) to which 162 nations are currently parties (as of 3rd June 2011).** UNCLOS is considered the binding customary international law. UNCLOS establishes the rights and duties of all states concerning the seas and oceans on Earth, balancing the interests of coastal states in offshore zones with the interests of all states using the oceans. This international treaty governs the overall legal status of practically all relevant questions concerning seas and oceans.

UNCLOS has relevance for the protection of submarine cable systems as it sets common standards for all State Parties. **Art. 21, 51, 58, 78, 79, 112-115, 297 contain provisions and obligations which are related to submarine cables and are the first acknowledged global step towards a common minimum framework on the issue with legal power.**

Art. 58, 78, 79 and 112 grant **freedoms** for State Parties to deploy submarine cables in the Exclusive Economic Zone and on the Continental Shelf of another State Party (but give certain rights and possibilities for the affected Party to steer the process) and on the bed of the

High Seas. These provisions allow for a fair balancing of the respective interests including the general possibility to deploy cables and expand the global network.

Art. 113-115 mandate obligations for State Parties to adopt certain legal provisions in their domestic laws which penalize the wilful or negligent damaging of submarine cable systems (113), which hold liable anyone damaging a third party's cable while deploying or repairing another cable (114) and which gives the right to compensation to every ship owner who sacrifices gear in order to avoid damaging a submarine cable. The provisions of Article 113 in particular are a very useful tool establishing a certain minimum level of protection for submarine cables throughout the world and even on international High Seas, which are not part of any State's jurisdiction and sovereignty.

Article 311 obliges State Parties to not enact laws that contravene UNCLOS. Therefore all measures taken by member economies have to and **should be assessed as to whether they contravene any provisions of UNCLOS.**

UNCLOS certainly is an adequate and very helpful instrument and has proven in recent years to be of significant use to the development of an improved submarine cable network.

1. **It is therefore recommended that all member economies become a State Party of UNCLOS, as far as legally possible**. This would allow member economies to benefit from UNCLOS' rights and freedoms, and allow its relevant provisions to become equally binding on all member economies.

2. **The required provisions of domestic law about cable protection should be enacted in accordance with Art. 113-115**. In turn member economies could then be assured of the compliance of all other State Parties to establishing the same minimum level of submarine cable protection.

3. All member economies which are State Parties **should comply with the requirements of UNCLOS and especially respect its provisions in the EEZ and upon the continental shelf**, where it limits domestic laws that restrict the freedom to lay and repair international submarine cables.

If a ratification of UNCLOS is not desired or possible, the member economies should enact provisions of domestic law establishing the same minimum level of submarine cable protection voluntarily and on their own behalf.

UNCLOS provides a very important international legal standard about the protection of submarine cables. Member economies should enact the requirements of UNCLOS as a first step. However member economies should also go beyond this and consider the measures which are recommended throughout this study, especially in Chapter 5.

According to information provided by the UN, the following is the s**tatus of APEC member economies' ratification of UNCLOS including the date of ratification**[64]:

[64] Chronological lists of ratifications of accessions and successions to the Convention and the related Agreements, Division for Ocean Affairs and the Law of the Sea, 2011

1. Australia (5 October 1994)
2. Brunei Darussalam (5 November 1996)
3. Canada (7 November 2003)
4. Chile (25 August 1997)
5. China (7 June 1996)
6. Hong Kong, China (following Hong Kong, China's own statement (see reply to survey), it is bound by UNCLOS as a part of the People's Republic of China)
7. Indonesia (3 February 1986)
8. Japan (20 June 1996)
9. Korea (29 January 1996)
10. Malaysia (14 October 1996)
11. Mexico (18 March 1983)
12. New Zealand (19 July 1996)
13. Papua New Guinea (14 January 1997)
14. Peru (according to available data neither signed, nor ratified)
15. Philippines (8 May 1984)
16. Russia (12 March 1997)
17. Singapore (17 November 1994)
18. Chinese Taipei (according to available data neither signed, nor ratified; no United Nations membership)
19. Thailand (15 May 2011)
20. United States (according to available data signed, but not ratified)
21. Viet Nam (25 July 1994)

This overview shows that the vast majority of member economies are full State Parties to UNCLOS. This is in line with the general international trend as 162 states have ratified UNCLOS so far. As stated above, State Parties should then enact required domestic law on submarine cables and comply with UNLCOS.

Convention for the Protection of Submarine Telegraph Cables

The Convention for the Protection of Submarine Telegraph Cables from 14th March 1884 is still in force and remains an important legal instrument in the protection of submarine cables together with UNCLOS, although it has only 23 State Parties. While the Convention's essential terms are included in UNCLOS now, it remains the only treaty that provides the detailed procedures necessary to implement them and therefore continues to be widely used in the cable industry. The Convention's age shows the long history and importance of submarine cable systems.

However, the fact that it remains the only international treaty entirely dedicated to the topic and that newer ones such as UNCLOS do not go much further in scope and content than the Convention did more than a hundred years ago, shows that **little has been done in international cooperation towards the protection of submarine cables. The topic has been somewhat neglected in international cooperation. This might change now, as nowadays data hunger and the reliance on submarine cables, have led to the massive deployment of fibre cables all around the globe and have lifted the topic to an entirely new level of importance.**

The main terms of the Convention are:

- Article 5 special lights and signals displayed by cable ships; minimum distances ships are required to be from cable ships;
- Article 6 minimum distance ships are required to be from cable buoys;
- Article 7 procedures for sacrificed anchor and gear claims;
- Article 8 competency of domestic courts for infractions;
- Article 10 procedures for boarding vessels suspected of injuring cables and obtaining evidence of infractions.
- Article 311(2) of UNCLOS recognizes the continued use of these provisions, which are compatible with and supplement UNCLOS.

Summary and assessment of international legal status

These two treaties of international law, UNCLOS and the Convention for the Protection of Submarine Telegraph Cables, create a common set of legal measures which include the following provisions:

- Freedom to lay, maintain, and repair cables outside of an economy's 12 nautical mile territorial sea
- Obligations for nations to impose criminal and civil penalties for intentional or negligent injury to cables
- Special status for ships laying and repairing cables
- Indemnification for vessels which sacrifice anchors or fishing gear to avoid injury to cables
- Obligations for owners with new cables that are laid over existing cables and pipelines to indemnify repair costs for any damage caused
- Universal access to domestic courts to enforce treaty obligations

These legal provisions, however, primarily aim to provide freedom to deploy cables and maintain them and to solve conflicts that may arise between different private parties involved. They create rules and obligations that set up a minimal degree of protection and address the most basic issues like ensuring repair works.

UNCLOS sets up a very important international minimum standard. Member economies should certainly enact the requirements of UNCLOS as a first step. However the treaties do not establish a comprehensive general framework that covers all aspects of cable protection and impact mitigation and all activities connected to submarine cables. Member economies should also go beyond, for instance by considering the measures which are recommended throughout this study and especially in Chapter 5.

In the long-term, member economies should aim at furthering this international law to include additional protection and mitigation measures as trans-border facilities like submarine cables require a common, international approach.

EXAMINATION OF CURRENT MEASURES

For both public authorities and cable operators, the measures taken can be differentiated into two groups:

- those aiming to **protect submarine cables** in order to prevent disruptions from happening at all and
- those **aiming to mitigate the impact** on the quality of data connection for the end users resulting from a cable disruption, as reducing or even preventing deterioration of data connection quality can prevent economic impact on the entire economy.

Public authorities

Although the current measures taken by member economies vary in scope and intensity as shown above, they all cluster around a certain limited set.

According to the data collected by both questionnaires, the responding economies have adopted some kind of legislative framework dealing with the topic of submarine cables. Whether the remaining economies have done anything in this regard is mainly unknown, due to lacking transparency and publication. It may be assumed that at least some have not done so.

The measures taken are:

- Permission and licensing requirements for deploying and operating submarine cables within the economy's territorial waters or Exclusive Economic Zones, and in some cases for repairing and maintaining them as well
- Establishment of penal offences for the intentional or negligent damaging of submarine cables
- Establishment of protection or no-anchoring and fishing zones around submarine cable systems: A zone is a legal entity where activities harmful to cables are banned.
- An obligation to display the position of submarine cables and/or the protection zones on nautical charts
- Regular military or coastal guard exercises aimed at the protection of submarine cables especially exercises countering terrorism, piracy and illegal anchoring
- In addition, a designated point of contact to coordinate and facilitate the stakeholder community in their respective economies was nominated by all eight member economies that answered the Australian survey following APEC TEL 39.

One important conclusion that can be drawn from this list is that the **focus of member economies is currently only on protecting submarine cables**, i.e. preventing them from being disrupted at all. This is in general a wise thing to do, as it is always better to prevent something bad from happening and to combat the causes rather than just dealing with the effects and treating the symptoms.

Additionally, as seen in chapter 2, there are natural hazards to submarine cables which are simply not preventable. And even man-made hazards will never be entirely prevented either. Hence, **measures mitigating the impacts of a cable disruption have to be taken** in order to prevent the economic damage which may be caused by cable disruptions. Recommendations concerning possible mitigation measures will be made in Chapter 5.

Best practice examples: Australia and Hong Kong, China

Some of the member economies have adopted measures in several, others only in a few of these fields.
However, as far as can be seen, there are only a small number of member economies that have set up a **dedicated strategy** for the protection of submarine cables and the mitigation of impacts. These initiatives are mainly part of larger strategies to increase the resilience of different facilities defined as "critical infrastructure".

Among these **exemplary economies are Australia and Hong Kong, China** which may serve as best practice and whose strategies shall be examined in detail.

Australia[65]

The Australian Government works closely with the owners and operators of submarine cables both domestically and internationally to increase the resilience of submarine cables to disruption from all hazards. Australia has also introduced regulatory provisions to aid the protection of submarine cables in and around Australia and undertakes significant international effort to work with international partners on issues that affect submarine cable resilience.

Telecommunications in Australia are generally regulated by the ***Telecommunications Act 1997***. The protection of submarine cables within territorial waters and the protection zones are provided by Schedule 3A of the Telecommunications Act, which was introduced in 2005.
This legislation establishes a scheme for the Australian Communications and Media Authority (ACMA) to declare protection zones over submarine cables of domestic significance in Australian waters and makes damaging submarine cables within a protection zone into offences that are punishable by fine or imprisonment.

Three submarine **cable protection zones** have been established in Australia, two off the east coast in Sydney, and one off the west coast in Perth. A number of activities likely to damage submarine cables are prohibited or restricted inside protection zones. These include trawling, anchoring, fishing, towing, mining or dredging. The legislation also makes provisions that activities that are related to marine and energy infrastructure but which may cause damage are to be undertaken only with the notification and consultation of cable operators. In addition, Schedule 3A requires carriers to apply to the ACMA if they wish to install a submarine cable in a protection zone or in Australian waters.

The *Submarine Cables and Pipelines Protection Act 1963* provides for the protection of submarine cables by implementing Articles 113 to 115 of UNCLOS. The Act makes it an offence, punishable by a fine or imprisonment, for a person to engage in conduct, including negligent conduct, which results in a ship registered in Australia or in an Australian Territory breaking or injuring a submarine cable. In addition, if a person owns a submarine cable, and in laying or repairing that cable causes a break in or injury to another cable, they will bear the cost of the repairs

Complementing the regulatory submarine cable protection regime described above is the implementation of the Australian Government's *Critical Infrastructure Resilience Strategy*.

[65] Response by the Australian Government to the Questionnaire (Annex)

This strategy generally takes a non-regulatory approach to critical infrastructure and recognizes that owners and operators of critical infrastructure are best place to manage risks to their operations and determine the most appropriate mitigation strategies.

Under the strategy, critical infrastructure is defined as follows:

"Those physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the social or economic wellbeing of the nation or affect Australia's ability to conduct economy-wide defence and ensure domestic security[66]."

A key component of the strategy is the operation of an effective business-government partnership with critical infrastructure owners and operators, including key submarine cable owners and operators in Australia. The Trusted Information Sharing Network (TISN) for Critical Infrastructure Resilience allows owners and operators of critical infrastructure and government to work together and share information on threats, vulnerabilities and cross-sector dependencies and to develop strategies and solutions to mitigate risk.

Submarine telecommunications cable infrastructure falls within the broader communications sector and as such all of the major submarine cable owners and operators in Australia participate in the Communications Sector Group (CSG) of the TISN. The CSG's purpose is to identify, analyze, discuss and share information on issues affecting the protection of Australia's critical communications infrastructure.

The CSG has undertaken a number of activities to increase awareness of the importance of submarine cables and the impact of disruptions, including impacts on other sectors. As an example, a desktop exercise was conducted in 2009 to raise awareness of the implications of a multiple submarine cable outage to the Australian communications sector and more broadly, to other critical infrastructure sectors, particularly the banking and finance sector.

Another important activity that the Australian Government undertakes to enhance submarine cable resilience is international engagement. This is done through membership in the ICPC, involvement with organisations such as APEC and bilateral and multilateral cooperation with key partners.

In summary, the Australian approach is comparably advanced and actively, comprehensively and skilfully deals with the issue of cable protection. However, there may still be room for improvement by adding further protective measures and setting up mitigation measures in line with the recommendations given in Chapter 5. This is especially important when considering Australia's special need for resilience as stated in Chapter 2.

Hong Kong, China

The authority responsible for the supervision and management of submarine cable systems in Hong Kong, China (hereinafter referred to as HKC) is the **Office of the Communications Authority (OFCA).**

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[66] The Australian Government, *Critical Infrastructure Resilience Strategy*, www.tisn.gov.au

The **Submarine Telegraph Ordinance** (Chapter 497 of the Laws of HKC) has been enacted in HKC for the protection of submarine cables and especially serves to enact penal offences for anyone wilfully or negligently damaging a submarine cable. The penalties of a fine of HK$ 500,000 and imprisonment of 5 years for wilful damages are quite high and are likely to create the necessary deterrence.

Among those APEC member economies which have already advanced in the field of cable protection, HKC is a leader and has established a comprehensive regulatory framework covering all of the common protective measures (see above for survey results).
The OFCA follows a dedicated and qualified approach to the protection of submarine cables and maintains a close and effective supervision and management of those cables running into the city. The results of the survey show that it is aware of all important factors affecting the network and actively manages it.

In addition to those protection measures applied in other economies HKC has established some further – presently unique - ones which clearly mean a significant improvement for submarine cable protection. Especially remarkable is the fact that HKC is so far the only economy to have set up mitigating measures – mainly due to the bad disruption impact experience following the earthquake in the Luzon Strait in December 2006 which also affected HKC severely.

Among these **additional measures, the following** are those which can serve as a role model to other member economies:

1. In order to enhance the collaboration and coordination among the relevant government departments and to ensure the timely processing of applications for the setup of new submarine cable systems, **OFCA acts as the single point of contact** to facilitate cable operators' applications for the necessary statutory approvals for landing submarine cables in HKC. Cable operators do not need to acquaint themselves with the application processes of the different government departments on issues related to submarine cables. Hence, they will save time and administration effort in this regard and new cables may be installed faster.

2. HKC has established a **reporting mechanism for submarine cable operators** which are required to report system outages according to the criteria and timeframe set out in the Guidelines for Cable-based External Fixed Telecommunications Network Services Operators and Internet Service Providers for Reporting Network and Service Outages issued by OFCA. This is a very helpful tool **allowing OFCA to maintain a continuous and comprehensive** overview of the current status of each cable and the entire network and enables OFCA to take impact mitigation measures when needed.

3. OFCA has established an **Emergency Response System ("ERS")** to deal with emergency incidents that have resulted or may result in disruptions to the public telecommunications services including breakdowns in submarine cable systems. The ERS is operated by OFCA's Emergency Response Team ("ERT") which is on standby round the clock and 365 days a year. The ERS is activated, among other things, as soon as the ERT receives a report on submarine cable system breakdown. The ERT will ensure that an immediate and coordinated response will be taken by the relevant operators to restore the affected services, if any, as soon as possible. For critical incidents which have significant and territory-wide implications, OFCA will alert the public through TV and

radio broadcasts. The operators concerned will also activate their contingency plans to deal with the incident. In general, they will divert the affected traffic to available alternative routes.
This prudent measure bundles competencies, builds up concentrated skills in emergency handling and enables OFCA to respond to every incident in the shortest time possible and to take the best and proven mitigation measures based on their lasting experience.

4. Another advanced and effective mitigation measure which aims to keep the impact of a cable disruption as small as possible was the setup of the **Regional Internet Resolution Site in HKC**. After the big earthquake near Chinese Taipei in 2006 authoritative root name servers associated with certain international domain names which are mostly situated overseas were unreachable. To overcome this shortfall, Hong Kong Internet Exchange ("HKIX") collaborated with the relevant authoritative directory provider and established a Regional Internet Resolution ("RIR") Site in HKC, brought into operation in February 2008. With the establishment of the RIR consumers, including the business community, will no longer have to rely solely on overseas authoritative root name servers to access certain domain names and will still be able to enjoy uninterrupted internet usage in most cases of submarine cable disruption.

5. In order to reach a high level of protection of submarine cables against intentional damage, the **activities of the Marine Police of HKC, already mentioned in the context of the surveys, concentrate specifically on the protection of submarine cables.** Marine Police has a specific operation order governing police response to any report of possible submarine cable break and damage and commands a fleet of over 100 crafts patrolling the waters of HKC around the clock. Simultaneously, the Command and Control System of the Marine Police, equipped with modern high-tech surveillance equipment, also monitors illegal activities (including tampering with submarine cable) within HKC waters.

Cable operators

The submarine cable operators also apply certain measures to protect the cables. **It is the operators who care about deployment, maintenance and repair of the cables and this makes perfect sense as explained above.** Hence, there are few or no obligations in place in member economies on certain protection measures and standards to be observed by the cable operators, e.g. technical norms. For example, Hong Kong, China stated that "it is the responsibility of owners of the submarine cables to carefully assess the potential risks before laying the submarine cables"[67].

Hence, the decision as to what kind of measures to apply, what investment effort is required, and which degree of protection is to be attained, are to a large extent at the discretion of the individual operator. It may be assumed that with 37 cables in scope, run by a multiplicity of operators, the standards applied are not the same throughout all cables in all regions.

This however means that there is no clear picture as to when and what measures are used and applied by operators in order to protect submarine cables. So there is not sufficient data to

[67] Answer to Australian survey following APEC TEL 39, 2009

assess the difference in scope and intensity of those measures taken by different cable operators.
As shown above, many of the responding member economies require permissions or licenses prior to the installation of submarine cables. These could, in general, include conditions to comply with certain technical and protection related standards and therefore could be an effective vehicle for the enforcement of such measures. However, it is important that these requirements do not hamper deployment of additional cables.

There are certain technical standards that are state-of-the-art the cable industry applies for the production and deployment of sea cables (cable armouring, cable burying etc). These are very important and crucial measures for the protection of cables. Universal standards for this kind of protection measure commonly agreed between the member economies and the cable industry throughout APEC could further increase the overall level of cable protection.

Their details are described below.

1. The deployment of a dense and geographically diverse network of submarine cables is the most effective way of preventing cable disruptions from having a negative impact on the data connectivity of a member economy as it allows for re-routing of traffic. Therefore, the ongoing deployment of additional cables by the operators, ideally in a geographically more diverse way, is the most important step towards more network resilience and member economies should support cable operators in doing so.

2. **Effective mitigation measures** are adapted as well. Operators aim at a timely **repair of damaged cables**, **re-routing of traffic** and traffic management through agreements or on a situational basis and other business continuity measures. Despite sometimes serious cable breakages the global cable network generally continues to function because of these measures.

   The most important of these mitigation measures taken is the immediate **re-routing of traffic** using spare capacities on other submarine cables along with fast cable repair operations. **Cable repair vessels for example are on standby at strategically located ports around the world.** Cable operators efficiently organize the repair and pool resources by concluding Cable (Repair) Ship Arrangements and Cable Maintenance Agreements.

   Concerning traffic re-routing, some operators have adopted quite advanced **system restoration and business continuity plans** which considerably reduce outage times even after the occurrence of big natural disasters. Measures for example can be to install responsible officers to coordinate actions (e.g. Overall Restoration Liaison Officer (ORLO)), to have concluded pre-arranged restoration plans between operators - where each party establishes backup circuits on the other’s cables (Private Bilateral Restoration (PBR)), and to make sure that damages to single cables do not decrease overall network performance by setting up sufficient redundancies, multi-diversified mesh networks and ring protection / auto switching.

3. The physical **protection measures** taken by cable operators work quite well. These **measures** cover the **creation of physical, technical barriers improving the protection against disruption by outside forces**. These measures mainly consist of three points:

- The core part of the protection measures is a protective shell around the cable to protect the optical fibres from the hostile marine environment.
- The seabed along the route is raked in order to prepare it for cable deployment and to remove dangerous items. It is then ploughed and the cables buried into the seabed.
- The exact route of the cable is explored by a survey vessel before its deployment, aiming at finding the optimally balanced short but safe route

These measures are described in more detail in **APPENDIX I**.

Cooperation and organization of cable operators

There is a certain degree of c**ommon organization and cooperation between the cable operators**. This is especially done in private associations like the United Kingdom Cable Protection Committee (SubSea Cables UK) (formerly known as UKCPC), North American Submarine Cable Association (NASCA) and the International Cable Protection Committee (ICPC). These organizations serve to exchange experience and knowledge but also serve as a basis to make joint decisions on questions of common interest and develop common points of view.

One example of global organization forum which deals with submarine cables is the **ICPC.** This is an international forum with 122 members from 60 economies (as of March 2012) who own or operate submarine cables around the world. A noteworthy development is that it now **also includes a membership category for governments** as well as marine survey and cable supplier categories. The governments of **Australia and Singapore** were the first to join. In doing so the ICPC is moving away from being a special interest group of the cable industry to providing a **forum in which all concerned stakeholders may exchange their ideas on cable related issues and find common views**. This surely is the right way forward, as it allows for a close cooperation between member economies and the cable operators in a process of open and transparent discourse where future measures on cable protection and impact mitigation may be determined.

The ICPC's vision is "to be the premier international submarine cable owners' association, providing professional recommendations on issues related to submarine cable planning, installation, operation, maintenance and protection.[68]" Its activities encompass the development of minimum industry standards, education of stakeholders, share information, implementation of projects and monitoring of the applicable law. So-called cable awareness charts are prepared for all vessels to prevent accidental damaging.

This sort of cooperation is very important as it yields important experience, strategies and ideas for the protection of submarine cables and therefore should be supported further.

[68] An Introduction to the International Cable Protection Committee, ICPC, 2010

ASSESSMENT OF CURRENT MEASURES

General: Some are in a good position, most have not yet started

As can be seen above from the surveys, the **measures taken by the economies that responded vary considerably in intensity and scope**. Some exemplary economies like Australia and Hong Kong, China have already taken quite advanced and robust steps to protect their submarine cable systems, e.g. the introduction of strict penal provisions on the damaging of submarine cables, the introduction of cable protection zones, and a clear and effective organizational setup.

However, the wide range reaches from some individual measures to broader strategies aimed at the integrated protection of critical infrastructure. This kind of disparity is especially disadvantageous in the field of submarine cable protection and impact mitigation as these cables are by nature "international". **Any effective attempt to achieve the named objectives would therefore require multilateral cooperation for submarine cable management**.

Overall, based on the received responses and conclusions, the average level of protection by the economies has to be described as "improvable". This may be due to the fact that many economies are unaware of the critical importance of submarine cables, as the Singapore ambassador to the UN stated[69]. The member economies' interest in submarine cables is still often limited to competition and licensing issues for telecommunications companies, rather than addressing their **crucial role as a critical infrastructure for social, cultural and economic prosperity and domestic security**.

Main lessons learned about necessary improvements

1. Only a few member economies have implemented at least a minimum set of protection measures so far**. In the long run all member economies should reach this position, and implement those measures taken by the exemplary economies and those recommended in Chapter 5.** Even these few exemplary economies have a diverse set of measures, stressing some issues but neglecting others, rather than aligning regionally and within APEC to reflect the trans-border nature of submarine cable systems.

2. **An aligned and coherent approach is necessary throughout APEC to create a common framework on submarine cable protection and mitigation** which has the features of being preventative and collaborative, and which combines protection and impact mitigation measures. Member economies should avoid concentrating on protection measures limited to the cables.

3. A comprehensive view should also include advanced mitigation measures and protection measures for **other crucial parts of the overall network such as repair vessels, landing stations and IT systems.**

[69] Guard the submarine cables that link us all, Tara Davenport, 2010

Importance of cable repairs, repair vessels and improvements from current measures

One important component in the overall system of fibre networks are the **vessels repairing and maintaining the existing cables**. As disruptions caused by natural hazards will never be entirely preventable, appropriate repair capacities are crucial to the achievement of short back-to-service times for damaged cables.

Hence, their assessment and the clear attention of public policies on this presently neglected topic are crucial.

The actual repair of cables, its organization and timing, the deployment of ships and, if necessary, the prioritization of repairs, in case demand and supply of repair capacitates mismatch, rely on the cable operators. **Their approach must be monitored to ensure that it sufficiently reflects the dangers of network outage to an ICT based society and economy, along with the overall network importance of submarine cables**:

1. In some regions there may be only a **limited number of cable repair vessels** (see Chapter 2). The long distances these ships sometimes have to travel to reach the site of a disruption increase repair times. **Member economies should be informed about the availability of repair vessels in their area**, monitor the situation, and take action if repair times are repeatedly significantly delayed due to a lack of vessels.

2. In some cases there may be a **lack of transparency on the cable status and repair operations.** There is generally no comprehensive overview of the current operational status of submarine cable systems. As far as is known, only Hong Kong, China requires cable operators to report cable outages and thereby provide the information necessary to monitor and facilitate repair works. Without this knowledge, member economies have no way of implementing fast response measures and are probably restricted to taking delayed steps once the disruption has already caused a perceptible problem like an outage. There is no need for strong intervention but information about cable status is a prerequisite for cooperation between member economies and cable operators. **It is therefore advisable to create the necessary transparency using general, real-time monitoring of the cable status** along with a duty for operators to report all incidences and repair processes.

3. In cases where there are a **limited number of repair vessels,** these ships just **do not have the time to remain idle waiting** at any one location.

   This fact becomes especially important where **member economies require permits and fees for repair works performed in their territorial waters or the Exclusive Economic Zone**.

   This requirement will have its purposes, such as control of the sovereign territory of an economy, the protection of the submarine cables themselves against unauthorized access, and the establishment of a certain degree of transparency. However, monitoring activities would achieve these objectives as well, and the requirement for permits and fees typically turns out to be a **severe obstacle and danger to rapid, good repair and maintenance** because operators are often forced to deal with several different authorities and obtaining the permit takes a long time because of inefficient bureaucracy. This leads to delays in repairs and direct costs to the operator, but most importantly to potential major indirect costs to the economy as a whole caused by the weakened network stability.

All member economies which are State Parties to UNCLOS should commit with their obligations under UNCLOS, which grant innocent passage status for cable repair vessels undertaking repairs.

Therefore, it has to be emphasized that member economies should generally not require permits or fees for the exercise of cable repairs. The administrative procedures involved in many cases significantly delay the necessary repair work. This puts the overall network stability at risk and member economies thereby impair their own interests of stable, uninterrupted data connectivity.

Alternatively, member economies which regard permit requirements to be necessary should expedite their official processes by establishing single points of contact or competence centres serving as a one-stop-shop for operators applying for permits, thus reducing processing times to the absolute minimum**.**

Hence, member economies should abolish such requirements and fees or should expedite the processing of permits significantly.

Missing international cooperation and alignment

Submarine cables transit through various economies' territorial waters. As such, while an economy may have a resilient and well protected cable system at its end, if the cable passes through or lands in an area that is less protected, the security measures in place could be in vain. **Submarine cables are only as secure as their weakest point**.[70]

There is often no lead agency responsible for submarine cables in a member economy that could represent the member economy internationally in the necessary process of cooperation and alignment. **Each member economy should set up a domestic lead agency responsible for submarine cables to bundle all competencies in this area. In addition they should name a single point of contact for cable operators.**

A major issue related to the protection of submarine cables and the setup of mitigation measures is the establishment of regional and international cooperation and alignment. So far, there is no international agency responsible for submarine cables. The International Telecommunications Union (ITU) is the UN agency overseeing information and communication technology issues, but it primarily deals with standards in telecommunications and does not currently seem to be an adequate body for international cooperation in submarine cable protection matters.

However, stronger cooperation and alignment is needed in order to reach the aim of a unified and coherent approach creating a common framework on submarine cable protection and mitigation which takes the trans-border nature of the systems into consideration. International organizations such as ICPC could also play an important role in the protection of submarine cables as it could provides a forum where all relevant stakeholders including cable operators and economies are represented and can discuss current cable protection issues.

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[70] Response by the Australian Government to the Questionnaire (Annex)

5. RECOMMENDATIONS FOR FUTURE PROTECTION AND IMPACT MITIGATION MEASURES

TRADE-OFF BETWEEN INVESTMENTS IN PROTECTION AND POTENTIAL LOSSES

As shown in Chapter 4, there are good reasons for member economies to develop a stronger interest in the protection of submarine cables and impact mitigation, taking into account the immense importance of these systems to modern economies and the potential losses which may occur in case of disruption. It is therefore recommended that member economies engage actively in the matter, monitor the sector more carefully, and consider taking appropriate measures as proposed throughout this study.

This engagement could involve some expense for the member economies. For example where resilience is to be increased through the deployment of additional geographically diverse routes, but these are not commercially interesting, they can only be financed with public subsidies. In times of tight public budgets this may be a difficult step to take.
However, geographically diverse cable routing allowing for traffic re-routing is the most effective measure to prevent traffic outages. Therefore, especially when **certain choke points have been identified which are not sufficiently addressed via private initiative, member economies should apply a cost-benefit-analysis to determine whether public spending can be justified for a specific cable project**. It may be prudent to invest and engage in order to prevent worse things from happening.

It is always a **difficult trade-off determining which resources should be applied to prevent accidents like cable disruptions which are of unknown likelihood and magnitude.** Member economies might find themselves spending more than what is actually necessary, or might not do enough and pay a far higher price later when a major cable disruption event occurs. The task is to find the right balance between resilience and the protection of domestic security, economic prosperity and social welfare on the one hand, and public spending and state intervention into the economy on the other.

Policymakers face conditions of considerable uncertainty and fiscal constraint. The findings of this study and the economic impact model should help support decision making. It provides information, recommendations, and a methodology to assess the potential cost of cable disruptions. This knowledge can be applied in the necessary cost/benefit analysis.

Considering the potential for substantial economic loss arising from cable disruption and the high likelihood of severe disruptions in some regions, an **overall recommendation is for member economies to sharpen their focus on the issue of submarine cable protection and risk mitigation. A ‘wait and see’ approach may be tempting, but is too risky as too much is at stake.**

RECOMMENDED PROTECTION MEASURES

As shown in Chapter 4, submarine cable protection can still be improved considerably. A series of potential protection measures which can be taken by all member economies is depicted below. These include some that are already in place in some member economies. **But especially those that have not yet enacted any or only a few measures should rectify the situation quickly.**

The rationale of every measure and the use it has for the member economies will be briefly described, along with the level of need / urgency.
All highly recommended measures should be implemented in the short term. The remaining measures should be considered and action taken soon as well, but their implementation timeframe may vary depending on the complexity of the involved tasks.

Most measures are feasible in the short-term (implementation timeframe) and cause little expense for member economies as they are mainly legal and administrative measures. Providing the necessary knowledge and expertise for all member economies, however, requires the long term build-up of capacities, especially in developing economies, and is an opportunity for cooperation throughout APEC (knowledge sharing and mutual aid).

A detailed evaluation and further cost/benefit analysis would still be necessary for each measure to be applied and adapted in each member economy.

Measures concerning the cable system and its facilities

No.	Measure	Rationale	Necessity
1.	Establish penal offences for the intentional or negligent damaging of submarine cables (in compliance with UNCLOS where applicable).	Most damage to submarine cables is done by ships and fishermen who do not have a sufficiently high level of awareness for these systems. They have to adapt their level of diligence to what is necessary to protect seacables. Penal offences may prevent careless, hazardous behaviour like anchoring, fishing and dredging around submarine cables.	Highly recommended measure
2.	Establish tort law liabilities for everyone intentionally or negligently damaging submarine cables and establish insurance obligations for ship-owners.	Most damage to submarine cables is done by ships and fishermen who do not have a sufficiently high level of awareness for these systems. They have to adapt their level of diligence to what is necessary to protect seacables. Tort law liabilities may prevent careless, hazardous behaviour around submarine cables like anchoring,	Highly recommended measure

		fishing and dredging, whereas insurance obligations (similar to cars) guarantee fast compensation for the cable owners and expedite fast repairs.	
3.	Establish protection or no-anchoring and no-fishing zones around submarine cable systems and landing stations and educate fishermen about the importance of submarine cables.	Keeping potential hazards away from submarine cables is one of the most effective indirect cable protection measures and could prevent most of the currently occurring negligent damage. Unauthorized access by potential wilful wrongdoers can also be detected by this measure.	Highly recommended measure
4.	To seek an agreement with cable operators on technical standards for the cables, including a protective shell for the cable and the repeaters and ploughing of cables into the seabed.	These basic protection measures are the most effective and important direct protection for cables	Recommended measure
5.	To seek an agreement with cable operators on protection measures for the network management systems (protection against cyber attacks), for the landing stations (physical protection and staff), and for the cable repair vessels.	Like the cable itself all additional facilities in the overall system are important for the functioning and business continuity of the data transmission and thus deserve the same degree of attention and protection	Recommended measure
6.	Develop a coordinated process among relevant public agencies to protect installations against piracy, terroristic attacks or sabotage and provide a fast and coordinated response in such an event. Deploy and train naval forces for such events.	Submarine cables and especially the more easily accessible land stations might be subject to intentional damaging similar to other critical infrastructure and member economies should be prepared for this threat.	Recommended measure
7.	Facilitate the application of Automated Identification Systems	The application of AIS would help to identify and locate all vessels in a critical proximity to submarine	Potential measure to be considered by member economies

	(AIS) for all vessels.	cables and provide early warning against hazards from fishing and anchoring.	

Measures concerning the cable routing

No.	Measure	Rationale	Necessity
8.	Minimize requirement to obtain permission for cable deployment and replace with monitoring and information measures (registration).	Establishing transparency about the existence and routing of submarine cables is a prerequisite to protecting them. Lengthy permission requirements hamper the deployment of additional redundant cables (which is the most effective measure to increase overall network resilience). In case member economies want to keep up permission requirements this process has to be appropriate and efficient and follow a one stop procedure (timely procedure for permits and visas) in order to reduce delays to a minimum.	Highly recommended measure
9.	Establish mapping requirements mandating the display of submarine cable systems and/or the protection zones on nautical charts.	Together with the establishment of protection zones, the display of submarine cables on charts will keep potential hazards away from submarine cables and prevent negligent damaging by anchoring, fishing and dredging.	Highly recommended measure

Measures concerning the cable repair process

No.	Measure	Rationale	Necessity
10.	Minimize requirement to obtain permission for cable repair and replace with monitoring and information measures.	Lengthy permission requirements are a main impediment in the quick and effective repair of cables and thereby undermine overall network resilience. In case member economies want to keep up permission requirements the process must be appropriate and	Highly recommended measure

		efficient and follow a one stop procedure (timely procedure for permits and visas) in order to reduce delays to a minimum.	
11.	Monitor the status of the submarine cables, oblige operators to report all incidents and repair processes and monitor the cable repair process.	Establishing transparency about the status and disruptions of submarine cables is a prerequisite to being well prepared for their protection and to taking action where necessary.	Recommended measure

RECOMMENDED IMPACT MITIGATION MEASURES

As shown in Chapter 4, mitigation measures are not at a sufficient level in most member economies and should be improved. A series of potential mitigation measures is depicted below which can be taken by all member economies. Only very few of these measures are already in place in member economies. All member economies should therefore improve the situation here.

The rationale of every measure and the use it has for the member economies will be briefly described along with the level of need / urgency.
Most measures are feasible in the short-term (implementation timeframe) and cause little expense for member economies as they are mainly legal and administrative measures. Providing the necessary knowledge and expertise for all member economies, however, requires a build-up of capacities and is an opportunity for cooperation throughout APEC (knowledge sharing and mutual aid).

A detailed evaluation and cost/benefit-analysis is necessary for each measure in each member economy.

Measures concerning the overall network resilience

No.	Measure	Rationale	Necessity
12.	Establish incentives to help create new, geographically diverse routes (via sea or land; additional landing points for cables etc.), especially at critical chokepoints and through cooperation with operators and investors (e.g. public companies, PPP, subsidies).	This measure improves the resilience of the overall submarine cable network, creates geographic diversity and new redundant cables. This is the most effective measure to prevent disruptions from causing traffic outages even after multiple-cable-breaks in a certain region caused, for example, by major storms or earthquakes. This could also include overland cables, which may complement submarine cables, especially at	Possible measure member economies should consider This is a long term measure requiring dedication by the member economies and the build up of a certain expertise in the field. It is advisable for this to be done with a

		certain chokepoints.	common approach.

Measures concerning traffic management

No.	Measure	Rationale	Necessity
13.	Assess advantages and disadvantages of traffic management systems, including IP deep packet inspection and Quality of Service standards.	Permission for operators to use measures like IP deep packet inspection and Quality of Service standards could help to prioritize types of traffic in case of cable disruption and could be useful to minimize economic impact. However, permission to generally apply such measures could create adverse incentives as it would then be less necessary to provide excess bandwidth capacities. Hence, resilience and redundancy would even be lower than before. Additionally, network neutrality and data protection are major arguments against these measures. However, in a very limited emergency situation these measures could prevent dangerous economic impacts.	Possible measure member economies should consider
14.	Request operators to prepare comprehensive business continuity plans, monitor their preparation.	Typically cable operators have prepared business continuity plans which depict steps to be taken in case of damage/disruption - including re-routing of traffic, repair processes, and safeguarding of important domestic or business-critical traffic, e.g. by pre-arranged restoration agreements between operators. Establishing transparency about the status of these measures is a prerequisite to being prepared for cable protection and to taking action where necessary.	Possible measure member economies should consider

General measures

No.	Measure	Rationale	Necessity

15.	Setup of a single point of contact for all relevant stakeholders; setup of a situation room, or staff unit at a competence centre.	A single point of contact for cable operators where they could report any emergency or suspicious activities impacting cables, would allow member economies to organize a quick and comprehensive response to any threat. Establishing an emergency unit that may react quickly in all urgent cases may reduce reaction times and help to prevent any negative impacts from disruptions.	Highly recommended measure
16.	Stronger cooperation in APEC and regional setup of joint bodies establishing common standards and aligned strategies on the issue	The issue of submarine cable protection requires international cooperation because of their cross-border nature. A common approach of member economies to cable protection would increase the effectiveness and efficiency of the protection efforts.	Highly recommended measure
17.	Stronger cooperation between cable operators and member economies in the ICPC (or other similar international organizations) and UNCLOS	Cooperation between the member economies and cable operators e.g. in common organizations like ICPC, increases the effectiveness and efficiency of cable protection measures.	Highly recommended measure
18.	Setup of a modern, comprehensive and appropriate legal framework for submarine cable protection and impact mitigation, bundling and streamlining all efforts - most recommendable as a part of a general strategy for the protection of critical infrastructure.	Bundling all efforts and measures concerning submarine cable protection and impact mitigation in a comprehensive framework and overall strategic approach increases transparency and efficiency for member economies. It helps to consolidate and streamline measures, identify gaps and overlaps.	Highly recommended measure Basic measure which serves as a legal foundation for the implementation of the other measures.
19.	Setup of a dedicated body bundling responsibilities and implementing all measures, monitoring operators and the	Bundling responsibilities and competences increases the effectiveness and efficiency of the protection efforts and leads to an increased level of protection and	Recommended measure

	situation (competence centre, lead agency); located for example at the domestic regulatory authority for telecommunication;	impact mitigation. The body could develop clear policies on submarine cables, prepare necessary measures and legislation and implement the overall recommended strategy on submarine cables.	

OVERALL OBJECTIVE

Member economies should devote stronger dedication to cable protection and impact mitigation. There is no need for intensive intervention. The cable operators generally provide for a sufficient redundant deployment of submarine cables and basic protection measures. Overly strong intervention could even hamper investments in additional cables which would be dangerous as a diverse cable network is the best measure to prevent traffic distortions. Instead a business-government partnership approach should be pursued using appropriate entities for international cooperation and alignment such as the ICPC.

Through a collaborative partnership with submarine cable owners and operators, member economies will be able to tap into the expertise and knowledge of the industry to gain insight into issues, threats and hazards impacting submarine cable protection, while at the same time being able to influence and shape the thinking and actions of the industry.

Member economies must get informed about the status of their respective cable systems, get a comprehensive overview, monitor the situation, and take individual measures in accordance with those measures recommended throughout this study and in Chapter 5 where necessary. For this to be achieved, human capacity must be strengthened, streamlined and efficient dedicated working bodies established; and modern, meaningful legislation enacted and enforced.

GLOSSARY AND ABBREVIATIONS

Abbreviation	**Meaning**
ACMA	Australian Communications and Media Authority
ADSL	Asymmetric Digital Subscriber Line
AIS	Automated Identification Systems
APEC	Asia-Pacific Economic Cooperation
APEC TEL	APEC Telecommunications and Information Working Group
AU	Australia
BPO	Business process outsourcing
CAGR	Compound Annual Growth Rate
CIR	Critical Infrastructure Resilience
CLS Bank	Continuous Linked Settlement bank
DA	Double armour
DWDM	Dense wavelength division multiplexing
EEZ	Exclusive economic zone
ERS	Emergency Response System
ERT	Emergency Response Team
EVDO	Evolution data optimized
FTTC	Fibre to the curb
FTTH	Fibre to the home
GDP	Gross domestic product
Gbit	Gigabyte
Gbps	Gigabytes per second
HD	High Definition
HKC	Hong Kong, China
HKIX	Hong Kong Internet Exchange
IaaS	Infrastructure as a service
ICPC	International Cable Protection Committee
ICT	Information Technology and Telecommunication
IDA	Infocomm Development Authority of Singapore
IP	Internet protocol
IT	Information technology
ITU	International Telecommunication Union
KM	Kilometre
LTE	Long term evolution
LW	Lightweight
Mbit/s	Megabyte per second
M	Meter
Msec	Millisecond
NASCA	North American Submarine Cable Association

NEC Corporation	Former Nippon Electric Company
NTT Communications	Nippon Telegraph and Telephone
OFCA	Office of the Communications Authority
ON	Global optical networking equipment
ORLO	Overall Restoration Liaison Officer
PaaS	Platform as a service
PBR	Private Bilateral Restoration
PPP	Public private partnership
P2P	Peer-to-peer
QoS	Quality of service
RA	Rock armour
RIR	Regional Internet Resolution
SaaS	Software as a service
SLA	Service level agreement
SLTE	Submarine line terminating equipment
SPA	Special application
SWIFT	Society for Worldwide Interbank Financial Telecommunication
Tbps	Terabytes per second
Tele-presence	Set of technologies, such as high definition audio, video, and other interactive elements, enabling telecommunication as if all participants were present at one location, which they are physically not.
SubSea Cables UK (formerly known as UKCPC)	United Kingdom Cable Protection Committee
UMTS	Universal Mobile Telecommunications System
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
US / USA	United States of America
USD	US dollar
TISN	Trusted Information Sharing Network
VoIP	Voice over IP
WiMAX	Worldwide Interoperability for Microwave Access
2G	Second-generation wireless telephone technology
3G	Third-generation wireless telephone technology

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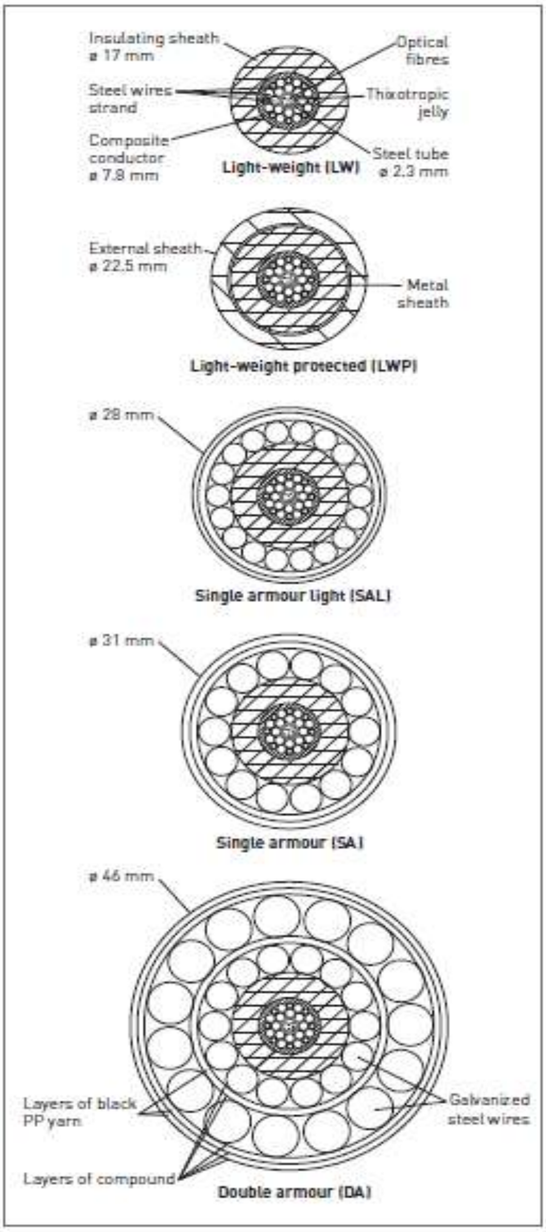
APPENDIX I

DETAILED EXPLANATION OF PROTECTION MEASURES TAKEN BY CABLE OPERATORS



Source: UNEP ICPC

Figure 20: Cross section of a submarine fibre optical cable

1. There are stringent industry standards applied in order to protect submarine cables including hundreds of repeater units which are installed approximately every 50-60 km along the routes. This is necessary to prevent damaging as the recovery and replacement of a damaged submerged plant involves considerable time, cost and probably disruption to service. A **core part of this standard is a protective shell around the cable to protect the optical fibres from a hostile marine environment**. The composition and gauge of this shell depends, to minimize costs, on the depth the cable is deployed at: In shallow depths close to the shore, where the likelihood of a cable being struck by anchors, nets and dredges is high, the armoured protection is rather heavy. Out on the high seas, where the cable rests on the seabed in depths of up to several thousand metres, the protection is comparatively thin and mainly serves to withstand the high water pressure, tensions induced during installation and recovery, and variable sea bed conditions like rocks or steep slopes.

   The types and names of the different cable armouring vary from rock armour (RA), double armour (DA), single armour, light-wire armour and special application (SPA) to lightweight (LW).

Cables are built around the fibre unit structure, which is a just two millimetre wide metal tube designed to house the fibres in a stress-free environment, and which contains a water-blocking tixotrophic gel and the actual glass fibres, with each fibre about the thickness of a human hair. For deep-water installation, the fibre unit structure is typically surrounded with several, twisted strengthening wires, a copper conductor leading electricity to the repeaters. This “light cable” is about 7 mm thick and is again surrounded by high-density polyethylene for insulation and abrasion resistance, giving a diameter of about 16 mm in total. In shallow waters, various levels of armouring using carbon-steel wires and bitumen sealant are built around this basic cable structure to protect it, composing the so-called rock-armour protection. Armoured fibre-optic cables may reach a diameter of 50 mm. Their length varies considerably but may reach up to 20.000 km (SEA-ME-WE 4). Cables like this are designed to withstand the marine environment for up to 25 years.

Repeaters and branching units are contained in pressure resistant structural housings made from specially blended alloys such as beryllium copper or nickel-chrome-molybdenum. Similar to the cable, they must also be able to withstand the tensions induced during installation and recovery and the high pressures of deep-sea installation.

2. In addition to this heavy armoured protection, in shallow waters close to shores it is a standard measure first to **rake the seabed along the route in order to prepare it for cable deployment and remove dangerous items, and then to plough and bury the cables into the seabed.** Cables are typically buried 1-3.5m under the seabed but this can extend to 10m in order to protect them from fishing and other activities. Burial may extend from the shore out to a maximum of 2000m water depth. This cable burial is a key protective measure and helps prevent most accidental man-made damage.

3. The **exact route of the cable is explored** by a survey vessel before its deployment, aiming at finding the optimal balanced short but safe route. This typically involves:
   - Selection of route
   - Assessment of potential impacts of cable laying in environment
   - Full survey of route & its final selection: Seabed mapping systems accurately chart depth, topography,
   - Slope angles & seabed type
   - Design cable to meet environmental conditions
   - Laying of cable
   - Notification of cable position
   - In some cases, a post-lay survey

APPENDIX II

Questionnaire for APEC Study on "Economic Impact of Submarine Cable Disruptions"

Relevant Ministries and Authorities in matters of economy, telecommunication infrastructure, security and protection of critical infrastructure and/or international cooperation in these fields

General Information

1) What is the **name** and location **of the authority**?
   Please indicate the names and contact details of all respondents who assisted in completing this questionnaire. (Please repeat the table as many times as necessary.)

Name and Designation:
Ministry:
Contact Address:
Tel. No.:
E-mail Address:
Which APEC economy do you represent?

Submarine cable connections

2) Which **seacable systems** towards other APEC member economies are currently **connected to your economy** (existing landing station) and what is their individual **capacity** (lit fiber pairs, wavelengths per pair, Gbps per wavelength, total capacity for each system (Gbps))?

No	Seacable system (s)	Capacity

3) Are you aware of any **plans** of the respective cable operators **to extend that capacity** in the near future and/or to **install any new systems**? (Please mention the expected year, capacity and other related details whenever possible).

4) What is the typical, **average daily volume of traffic** actually being transported via the submarine cable systems towards your member economy?

5) What is the estimated **percentage** of your member economy's **international data traffic** carried by submarine cables?

6) Which **links** to which other APEC member economies do you deem to be **especially important** and why?

Damages, disruptions and congestions

7) In which geographical areas and current cable systems do you deem the level of **protections / availability of alternative routes** to be **sufficient** to guarantee uninterrupted data flow in case of disruption of one or several cable systems (likely disruptions include damages by anchors, for example)?
   Please provide some explanation for your answer.

8) In which geographical areas and cable systems in place do you deem the level of **protections / availability of alternative routes <u>not</u>** to be **sufficient** to guarantee uninterrupted data flow in case of disruptions of one or several cable systems (likely disruptions include damages by anchors, for example)?
   Please provide some explanation for your answer.

9) Where do you perceive **traffic congestions to occur** with certain regularity as far as you know? What are the **typical reasons** (man-made like anchoring, fishing, dredging or natural)?

10) In which geographical areas do you perceive or expect **special threat of damages and disruptions** to the cable systems?
    Please provide some explanation for your answer.

11) Did the submarine cable systems in your member economy suffer from any **damage or disruption** during the last four years, and if so, what were

    a) the supposed causes;

    b) the time of blackout until full repair; and

    c) the approximate cost of repair?

Impact mitigation and cable protection

12) During times of blackout after events of disruption, what were the perceived **effects on speed and data availability** end users suffered from (quantities if possible, such as traffic loss, decrease in speed), if any?

13) Based on past **disruption events**, what was the **impact to your economy** in general and of key economic sectors such as Finance, ICT & Telecommunications, Manufacturing and International Business in a **qualitative** sense?
    Please also **quantify** this impact according to traffic loss, decrease in speed, GDP contraction, and/or **money** (estimations where necessary) whenever possible.

14) What would you estimate is the quantity of **importance and dependency of your economy** in general and of certain sectors such as Finance, ICT & Telecommunications, Manufacturing and International Business **from international data connectivity**?
    Please also **quantify** according to percentage of economic output, GDP value, and/or **money** (estimations where necessary).

15) What are the typical handling and **impact mitigation measures** being applied in case of disruption of submarine cable systems by the operators and by your or other public entities?

16) In case of disruption, how and where would the **traffic of the cable system typically being rerouted** as far as you know?

17) Are you aware of any certain preferences and/or **agreements of the cable operators on where to reroute the traffic** in case of disruption of your cable system, or is it done on a totally situational basis?
    How would you rate the **usefulness** of such agreements (not useful/ useful/ very useful)?

18) Have the operators already introduced or do they plan to introduce **Quality of Service** and traffic management measures, like **deep packet inspection** and traffic prioritization measures, which allow them to divert and differentiate traffic in terms of
    - elastic / inelastic,
    - important / less important,
    - requiring high / low reliability and resilience

    to be applied in case of congestion or, more importantly, disruption?

19) Is **deep packet inspection and traffic prioritization allowed** in your economy in similar situations or are you **in favor of allowing** the introduction of such measures, or do you deem data protection, for example, to be more important?
    Please explain your answer.

20) Is **your economy a Party to the UNCLOS** (The United Nations Convention on the Law of the Sea of 10th December 1982) and if so, have you introduced legislation that **implements the provisions** of UNCLOS regarding submarine cables (e.g. Art. 58,78, 79, 112-115)

21) What **measures** are in place in your economy from any party (public and private, domestic and international) concerning the **protection of seacable systems** and/or critical infrastructure in general?
    (Please specify legal source, content, type, and effectiveness, if possible.)

    *(**Examples for such measures could be (please refer to as much as possible)**):*
    - *Overall strategies for the protection of critical infrastructure;*
    - *Duty to obtain permits to survey and install a submarine cable or at least notification requirements for operators on cable setup; duty to use certain deployment areas*
    - *technical norms and definitions for seacable design; technical acceptance test duties; duty to take certain cable protection measures;*
    - *prohibition for ships to enter or anchor in certain areas (protection zones); supervision of ships close to cable systems;*
    - *criminal penalties and/or civil damages regimes (tort law) for injury/damage to submarine cables caused by willful conduct or culpable negligence of ships and persons etc.)*
    - *duty to routing/placement of all submarine cables to be mapped onto the navigational charts;*
    - *monitoring or supervising cable operation;*
    - *etc.*

22) What **measures** are in place right now, from any party (public and private, domestic and international), which you know about, concerning the streamlining, acceleration and/or supervision of **the repair of seacable systems** and/or critical infrastructure in general?
    (Please specify legal source, type, content, and effectiveness, if possible.)

    *(**Examples for such measures could be (please refer to as much as possible)**):*
    - *Duty to obtain permits to repair a submarine cable;*

- *Allocation procedures to secure the availability and most efficient distribution of repair vessels;*
- *monitoring or supervising cable repair processes;*
- *etc.*

23) What **measures** are in place in your economy from any party (public and private, domestic and international) concerning the **mitigation of the impact of disruptions** that have already taken place?
(Please specify legal source, type, content, and effectiveness, if possible.)

*(**Examples for such measures could be (please refer to as much as possible)**:*
- *Regulation and optimization of rerouting patterns in case of cable disruptions;*
- *cable redundancy setup plans via incentives, PPP or public funding;*
- *notification requirements for operators in case of distortion and disruption;*
- *rules on insurances or liabilities for operators and/or anyone damaging seacable systems;*
- *regulation of operator/telco company wholesale agreements or imposition of obligations/sanctions in order to give incentives to safeguard business/domestic critical traffic;*
- *setup of special (international) supervisory bodies, situation rooms or staff units for uninterrupted data traffic;*
- *etc.*

24) Do your measures and regulations in place for submarine cable systems take into account and **differentiate between the several zones of your coastal waters** (as set out in UNCLOS: territorial waters, contiguous zone, exclusive economic zone, continental shelf) and in which way do they do so?

25) Have you established a **single point of contact** and/or concentrated all competencies for your member economy for **submarine cable systems** in general and for cases of emergencies (damages disruptions)?

26) What **measures** and regulations of any kind (technical, financial, legal, organizational) within public bodies, towards the private operator sector, or between private entities **would you consider to be necessary** and helpful in order to

    a) prevent seacable disruptions to happen at all as far as possible; and

    b) mitigate the economic impact of such disruptions?

27) Which **geographical areas and cable systems** would you consider to be especially **at risk and vulnerable** to damages and disruptions, and therefore should be included into any kind of (publicly supported) strategy on redundancy building or protection of critical infrastructure (e.g. a list of priorities)?
Please explain your answer.