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Anchor damage to submarine power cables ? How can that happen and what can be done to avoid?

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ABSTRACT

Many submarine cables are damaged by anchors every year. Cable owners and insurance companies suffer substantial monetary losses in such incidents. They might wonder why this can happen in times when all submarine cables are mapped thoroughly on sea charts and vessels navigate with accurate satellite based navigations systems. This article explains why the risk of anchor damage to submarine power cables still exists.
This article explains different types of anchor entanglement with submarine power cables, notably emergency anchoring and unintentional anchor dropping.
Published statistics on damages on submarine power cables need to be evaluated with great care. Using them for asset management or risk assessment in specific projects might render inaccurate results.
Some legal aspects are touched. These aspects are particularly complex since submarine cable damage incidents often occur in international waters where the applicable jurisdiction is not quite clear.
Finally, some improvements are suggested for both cable owners and vessel owners, which possibly can increase the safety of submarine power cables.

1. Introduction.

The damage caused by anchors on submarine power cables amounts to millions of Euro every year. The reason for the high cost is that the repair of submarine power cables requires specialized vessels and equipment, as well as highly trained personnel. The repair vessels might be no available close to the damage site and might need weeks for mobilization of suitable equipment and vessel transfer. Depending on the degree of repair preparedness of the cable owner the time between the damage and the re-energization of the cable can be anything between four weeks and many months. In addition to the repair cost the cable owner usually suffers loss of income from electric power transfer.

If the damaged submarine power cable was supplying power to e.g. oil&gas rigs the offshore production might be halted, or expensive substitute electric power must be provided which creates additional costs.

It is known that anchoring causes a large share of damage to submarine cables. The exact percentage of anchor damages is varying largely depending on the cable type, location, and other factors.

Many cable owners believe that they have done the uttermost to protect submarine cables from anchoring. All submarine power cables are charted in official sea charts and their commercial derivatives. Naval officers know that an encounter with a submarine cable inflicts risk of loss of anchor, or risk of damage to the vessel. Every officer on board should be eager to avoid any contact with submarine cables. Still, vessel anchors hit and destroy submarine cables.

This paper tries to explain why this can happen, and also gives some advises on how to reduce the risk.

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Figure 1: An anchor encounters a submarine cable.

Source: Author.

2. Statistics.

Cable asset managers and insurance companies want to know the probability of anchor damages for a cable system they own or underwrite to. Statistics on damages of submarine power cables are published by various sources. However, they seem to vary largely with respect to quality and credibility.

For the understanding of statistics on submarine power cable damages it is important to discern between different submarine cable types:

- Submarine telecom cables. There are hundreds of thousands of kilometers of this type installed globally, a large portion of them deployed at large water depths (>500m) where they are inaccessible for anchors. The cables are slim (20-60 mm). In shallow waters they usually sport heavier armouring to provide better protection against mechanical impact.

- Array cables are submarine power cables connecting offshore wind turbines with the offshore transformer substation. They are frequently damaged during construction and maintenance in the OWF pushing up the insurance costs. Once the OWF is commissioned the area is usually closed for commercial shipping and fishing.

- High-voltage export cables and interconnectors run between land-based substations and/or offshore substations, e.g. close to OWF or oil/gas installations. These cables often cross shipping lanes with high vessel traffic density. The sheer number of vessels crossing the cable route makes them more exposed to unintended anchor drops.

The International Cable Protection Committee has published a report saying that 8% of submarine cable faults have been caused by anchors before 2007 and that the same figure was 48% in 2007-2008 (ICPC, 2009). The large difference is attributed to the introduction of AIS[2] in 2006 which facilitates identifying the vessel which might have caused an anchor damage. The report is related to submarine telecommunication cables, probably in the waters around the UK. Probably these results are not applicable on submarine power cables in other parts of the world.

The organisation Cigré is one of the largest trade organisations of the electric power grid industry. In 2020, Cigre published questionnaire-based statistics on damages on submarine power cables (Cigré WG B1.57, 2020). Only 22 damages were reported to Cigré for the reference period 2005-2015. Most probably, a number of damages were not reported in public. Maybe the cable owners feared that detailed reporting would influence legal proceedings on responsibility and indemnification in connection with the damage.

Great care shall be undertaken in using statistics for several reasons:

- They might cover a different type of cables than what the user has in mind.

- The statistics might cover a different geographic location than what the user has in mind.

- They might be outdated. The number of submarine power cables has increased strongly in the last decade. Recently installed cable systems and damage events might not be included in the statistics.

- Underreporting. There are reasons to believe that not all damages of submarine power cables are reported to the statistic compilations.

3. Anchoring.

Anchoring is a millenia-old tool to secure a vessel on station when quayside mooring is not possible. Anchors are also used as pivot points for advanced vessel manoeuvres in confined spaces, e.g. in harbours. All this is normally done in controlled procedures and there is seldom a risk for compromising submarine cables. Defined anchorage areas are generally avoided by cable route planners.

Anchors provide holding power only if the length of the deployed anchor chain is 3-6 times the water depth. Given the available length of anchor chain an anchoring at more than 100 m water depth makes little sense.

The anchors of a vessel underway are secured in the hawsepipes with pins or wires. Other securing means are chain stoppers to block the anchor chains from moving. The use of the windlass brake may be considered for temporarily securing the anchor.

However, anchors can be deployed in less planned/controlled manners, notably emergency anchoring or accidental anchor dropping.

[2] AIS (Automatic Identification System) is a scheme for vessel tracking. Vessels ¿300 GT are requested to carry and operate a transponder which transmits basic vessel data such as name, position, speed, heading etc.

3.1. Emergency anchoring.

In certain emergency situations the deployment of anchors can avert dangers to vessel, environment, health or life of the crew.

Malfunction of propulsion machines. This leads to loss of manoeuvrability of the vessel. The vessel may drift towards shore, reefs, or other vessels. The master may choose to drop anchor in order to stabilise the position or heading of the distressed vessel. Weighing different consequences the master may do this also with the knowledge of existing submarine cables where the anchor would strike.

Loss of rudder machine. A major electric or mechanical failure may impede the function of the rudder. The consequences and remedies would be similar to the previous bullet.

Fire onboard may call for an immediate stop at all expenses.

Risk of collision with another vessel may call for immediate reduction of vessel speed.

The deployment of anchors is not always a good remedy in the mentioned cases. Attempts of anchoring in waters with more than 100 m depth would be quite useless. However, sometimes anchors are deployed in sheer desperation or panic.

If a vessel meets really bad weather conditions close to the coast the master may choose to unsecure the anchor by releasing the chain stopper and wires, having the anchor only on the windlass brake. Now the anchor is ready for emergency deployment, should worsening weather conditions require it, just by remote control from the bridge. In this situation the windlass brake may fail and the anchor would go down.

The fate of the bulk cargo ship “MV Rubymar” may serve as a sad example: In transit from UAE to Bulgaria, she was attacked by a rebel group in the Red Sea and hit by an anti-ship missile in February 2024, causing severe damage. 24 crew members were rescued and the ship was abandoned. With a dropped anchor, she moved 70 km while not under command. It is assumed that the dragging anchor is the cause of disruption of three or four submarine cables in the Red Sea. The cables were data cables, still, the incident shows how dangerous emergency anchoring can be for subsea cables.

3.2. Unintentional anchor dropping.

Only in recent times there are several cases where dragged anchors have allegedly damaged or destroyed submarine infrastructure such as submarine telecom cables or power cables, but even gas pipelines. In times when we believe that commercial shipping is a highly industrialized activity with high security standards it is difficult to understand how a vessel can loose and drag an anchor without even noticing it.

The anchor securing components (chains stopper, wires) can fail. Failures can be caused by material problems such as fatigue, undersize, corrosion, or lack of maintenance.

Human errors can cause unintentional anchor release under passage. Unskilled crew members might have used the securing means in an impropriate way, or they might have reported to the bridge that securing means had been employed but they were not.

If the anchor chain is long enough the anchor is dragged over the seabed and may penetrate into the seabed. Also an anchor which is dragged over the seabed with a chain too short for safe anchoring, can still cause substantial damage to cables under the seabed.

Unintentional anchor dragging can go unnoticed by the vessel crew for quite a time. The engagement of the anchor with the seabed would potentially reduce vessel speed and also heading since the dropped anchor is on one side of the vessel. The autopilot of the vessel can compensate for this silently without issuing an alert signal. Dragging distances of several kilometres have been noticed. Reference (A. Di Padova, 2018) has a case study with a dragging length of 100 km which is in the same range as the “MV Rubymar” case mentioned above.

If an anchor is simply dropped without being dragged over the seabed the risk of hitting a submarine power cable is rather low but not zero.

3.3. Intentional use of anchors targeting submarine power cables.

Submarine communication cables have been attacked and severed in relation to warfare in more than hundred years. Favorite tools have been purpose-designed cable cutters and anchors. Many states destroyed foreign submarine cables, such as France, United States, UK, Germany, etc. However, deliberate destruction of submarine power cables has not been reported yet as by 2023.

The global situation has changed. The Russian war against Ukraine and the sabotage against the Nord Stream pipelines demonstrate that infrastructure for power and energy can become a target for attack. Unfortunately, submarine power cables as they are installed in these days can be destroyed with quite simple means.

4. How cables get damaged by anchors.

Anchors are designed to dig themselves down into the seabed to gain holding strength. To this purpose they are normally deployed with a long length of anchor chain and little or no vessel speed. This brings the flukes in a position to penetrate the seabed, providing holding strength.

5. Penetration Depth.

Anchors develop their holding power not primarily by their weight but by their penetration into the seabed. Large heavy anchors penetrate the seabed deeper and develop a larger holding power, necessary for large vessels. The penetration depth into the seabed depends on anchor design, anchor size and seabed properties, and other factors. The simplest rule of thumb is that the penetration depth is in the order of the length of the flukes.

A number of experiments and simulations have been published to establish the penetration depth of different anchor types into different types of seabed soil. Table 1 notes estimated penetration depth values for various classes of vessel size and different soil types (Sharples, 2011). The values must not be taken as recommended burial depth for submarine cables.

Table 1: Anchor penetration depth.

Vessel class	Typical length, m	Typical DWT	Typical anchor, tonnes	Hard ground	Firm soil	Very soft clay
				Penetration depth, m		
Seawaymax (Tanker)	225 m	10,000-60,000	2-10	1.5	2.1	7.3
Handy Size (Cargo)		28,000-40,000	5-7	1.5-2	2.5	7.3
Handymax (Cargo)	150-200	40,000-50,000	7-8	2	2.5-2.9	7.3
Panamax (Tanker or Cargo)	220	60,000-80,000	8-13	2	2.5-2.9	7.3
Aframax	250	80,000-120,000	13-15	2	2.5-2.9	7.3
Capesize (Cargo)		100,000-200,000	14-25	<2.2	2.9	9.2
Suezmax	*285*	120,000-200,000	15-20	<2.2	2.9	9.2
VLCC	*330*	200,000-315,000	20-30	<2.2	2.9	9.2
ULCC	*415*	320,000-550,000	20-30+	<2.2	2.9	9.2

Note. The numbers in Italics are not from (Sharples, 2011) but from (Theo Notteboom, 2022).

Source: Authors.

It is noted that, for dragged anchors, the fluke angle is a more important factor for the penetration depth than the anchor size. It is assumed that the anchor has a laying position in relation to the seabed so that the flukes can dig in. It is also noted in the reference that a slow dragging speed will increase penetration depth in comparison with a faster dragging speed.

It must be mentioned that other sources report different values for the penetration depth of anchors (Worzyk, Thomas and Karlstrand, Johan, 2011).

Submarine power cables are buried into the seabed to a depth between 0.5 and > 5 m. Large burial depth is usually chosen in areas of high vessel traffic density. If a dragged anchor penetrates the seabed deeper than the cable's burial depth they will get entangled. The cable might be simply torn off. In other cases the cable suffers a sharp bend or chafing off vital layers of the cable. The electrical insulation of the cable will be demolished leading to a short-circuit and immediate loss of power transmission in the cable. From this, the exact time of the anchor impact is known and facilitates identifying the "guilty" vessel.

Other degrees of damage are lighter and may remain undetected for a while. If the water-sealing layer of high-voltage submarine power cables is damaged but nothing else the cable may retain its electrical function until later, when the intruding water will have deteriorated the cable insulation and an electrical breakdown occurs. This can happen hours, days or weeks after the incident. In these cases, the identification of the "perpetrator" by AIS will be difficult since the exact time of damage is not known.

If this is well-known to the cable owners, why don't they bury the cables deeper to get them away from the most dangerous anchors? Deep burial of submarine cables protects them better from anchor threats but there are some drawbacks:

- Deep burial requires larger and more expensive trenching equipment
- Often, deep installation burial takes more time which increases the project cost
- In case of a cable failure the repair operation on a deeply buried cable is more expensive
- The heat generated in the cable at operation is removed less efficiently from a cable at great burial depth. To compensate for this, the cable needs to be designed with a larger conductor which can increase the cable cost substantially.

The choice of burial depth in the planning phase is always a compromise between costs in the investment phase contra cost incurred by possible future anchor damage. Often, the burial depth in the installation phase is decided in relation to risks in certain parts of the cable route. In habour entrances or cable crossings with shipping lanes the cables are often buried deeper since the risk of anchor dropping there is higher, simply due to the higher vessel traffic density.

6. Legal.

A damaged submarine cable incurs large cost both for repair and for loss of income since the repair can take months of time. If the cable has been damaged by anchor there is a good chance to identify the "perpetrator" by the analysis of AIS data, showing which vessels were at the "crime site" when the cable suffered a breakdown. The cable owner would try to claim indemnification for the suffered losses.

However, AIS transponders can be switched off. Navy vessels use to do so to cover their movements, and the illegal fishing fleet does the same. Also, the spatial or time resolution of the AIS data might be too low for proof vessel identification. In other cases the cable might have been damaged only little, maintaining its function for a certain time after the damage. Future court decision on liability will show if AIS tracking holds in the court room.

It is far beyond the frame of this paper to cover legal aspects in depth. Still, a few aspects shall be mentioned to illustrate the difficulties.

Legislation. According to which country's legislation shall the liquidated damage proceedings be held? Is it the vessel flag state, or the cable owner's home country, or maybe the vessel owner's country, or may be the insurance company's home country? The maximum amount of liability (liquidated damage) is governed by the Convention on Limitation of Liability for Maritime Claims (LLMC) from 1976. The LLMC was amended in 1996 with substantially higher caps for indemnification. In this context it is important to know which country's legislation is applicable in a specific case since different countries have signed to different versions of LLMC resulting in different liability limits.

Circumstances of the event. As mentioned above, some anchoring incidents are caused by unintentional accidental drop of anchor and subsequent dragging, such damaging the cabled. Other incidents might involve the decision of the vessel master to drop anchor, even knowing there is a cable and taking into consideration damaging it, but in the endeavour to avert major damage to environment, or danger to health or life.

This spectrum of circumstantial conditions of the event can be judged differently in the legislations of different countries. They might have different views on negligence, culpability, and responsibility.

Once the "guilty" vessel has been identified and the legislation has been decided, the case is not closed yet. It might be concluded that the cable owner had neglected to protect the cable properly according to industrial practice and taking into account the prevailing vessel traffic density. This would leave at least part of the responsibility on the cable owner.

It is worth noting that also the vessel owner has the possibility to claim indemnification if he has sacrificed an anchor in order to avoid damage to a submarine cable. This can happen if the master of the vessel has noticed an entanglement of his anchor with a submarine cable and decided to abandon the anchor just to avoid or worsen damages. However, this possibility, laid down in the 1982 United Nations Convention on the Law of the Sea, is only theoretical since commercial vessels have no technical means to release the anchor and chain quickly.

There are few published court-proven decisions, if any. The parties of such proceedings and arbitrations often want to keep the details with them.

7. What can the cable owner do?.

It is industrial practice today that cable owners perform a thorough risk analysis in the planning phase of a new cable project. Vessel traffic patterns are easily obtainable today. The cable owner would evaluate risk levels for different sections of the cable route. Also, the monetary consequences of possible anchor damages will be taken into account. This can be complicated since the value of transmitted electric energy and other market conditions are not known for the future. Balancing costs and risks, the burial depth would be decided for the cable route sections.

Situations can emerge during the useful life of the cable that call for an updated risk analysis. Vessel traffic pattern or other use of the sea may change over time. Also, changes in the energy price and the power supply situation in the end points of the cable can influence the cost/risk balance. An updated risk analysis may require an improved cable protection to fulfill the availability targets.

In many seabed soils the submarine cable has a tendency to creep up or down in the seabed. Therefore, some cable owners perform regular marine surveys along the cable route in order to see if the cable is still at the intended burial depth and position.

Sometimes, cable owners tried to safeguard their cables with air patrols or guard vessels. This is an expensive method, probably avoiding most of danger from fishing activity. However, it would hardly stop emergency anchoring or sophisticated enemy aggression.

Cable owners are encouraged to find a wealth of information on submarine cable protection on the Internet. The International Cable Protection Committee, ICPC, has published a number of free papers which can help cable owners to protect their cables.

8. What can the vessel owner / master can do?.

Since the vessel owner can be made liable for at least parts of the damage cost he imposed on the cable owner in case of an anchoring damage it is wise to implement some basic precautions on board:

- Apply redundant anchor securing devices and check them regularly
- Train your deck hands on proper handling of anchor securing devices
- Use the latest sea charts including Notices to Mariners

Be aware that you can be traced easily and made liable by AIS data. Forensic engineering can reveal anchor paint traces of the afflicted cable, and by this proof the identity of the "guilty" vessel.

Conclusions.

Anchoring poses a tangible threat to submarine power cables. The cable owner usually suffers substantial monetary loss if a submarine power cables is damaged by an anchor. Chances are low to get full compensation for these losses from the vessel owner. Even if statistics on how often submarine power cables are damaged by anchors are not good enough to calculate accurate risk numbers, cable owners can improve the safety of their cables if they provide adequate cable protection, based on a risk analysis. This would take vessel traffic patterns and economic consequences of a cable damage into account. Vessel owners can contribute to cable security by good crew training and material maintenance plans.

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