SUBMARINE CABLE RECOVERY AND RECYCLING

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Abstract: Since the first successful telegraph cable was laid across the English Channel in 1851 submarine cables, through various technical iterations, have developed to be the keystone of our modern inter-connected world. Through telegraph, coaxial and fibre optic cable developments, telecommunications companies have demonstrated continuous engineering innovation and in doing so have replaced obsolete cables. As cable systems taken out of commercial service they present a significant opportunity from a variety of perspectives. (science, reuse and recovery)
This paper will present an analysis of the risks and benefits of recovering obsolete submarine cables and illustrate the tangible benefits of this opportunity.

Key areas to be considered are as follows;

- Spatial Planning and the case for recovery of OoS cables
- Compliance with licencing requirements
- The materials these cables comprise are of the highest quality and present an opportunity to recycle valuable commodities.
- In Environmental terms, removal of these systems can make a significant contribution to the corporate, social responsibility of the parties to these systems in terms of their 'carbon footprint'.
- The environmental impact of submarine cable recovery in physical terms.
- Removal of radioactive materials from the marine environment.
- Removal of these systems offers benefits for new systems. Proven, reliable routes used by previous systems can be re used by new systems once they have been cleared.
- Recommendations developed and promoted by the ICPC provide a clearly defined framework for the managed recovery of these systems.
- Peer review and open communications across the industry reinforces this managed framework, before, during and after recovery operations.

1. INTRODUCTION

For more than 150 years, humankind has developed and become increasingly dependent upon submarine cables for communication. Today these systems form the keystone of our modern inter-connected world economy carrying approximately 97% (APEC 2012) [1] of all data traffic globally.

As technologies have developed, new and improved cable systems have been installed, progressively providing greater connectivity at an ever decreasing cost per unit of data transferred. Today there is more than 1 million KM of operational submarine cables serving society's ever increasing demand for inter-connectivity, but what about the now redundant systems that preceded them?

For more than a century, telegraph cable systems were installed around the world. These cable systems were then superseded by coaxial cables which provided telephone connectivity and these, in turn, were replaced by fibre optic systems.

Accurate numbers for the total km of telegraph systems installed are difficult to establish. By 1914 some 322,000 [2] nautical miles (596,000 KM) of telegraph cable had been installed and current best estimates by 1950, the start of the coaxial era, are in excess of a total of 469,000 [3] nautical miles or 869,000 KM.

The pace of installing coaxial telephone cables and early fibre optical systems increased during the second half of the 20th Century and by the year 2000 another 1 million KM of cable had been installed.

This figure has subsequently been matched in terms of in-service systems installed between 2000 and 2018.

As cable systems were upgraded the majority of these now out of service systems were left in situ, the focus being on developing new telecommunications systems and not cable recycling. This has more recently lead to a number of companies developing an economic model for the recovery and recycling of these legacy systems.

2. SPATIAL PLANNING

The chosen route for any new submarine cable is designed to achieve a number of objectives, not least of which is the reduction of risk to the efficient operation of the system concerned and other pre-existing cables or pipelines. Route planning often looks to pre-utilised routes, to minimise latency, which have previously facilitated the successful installation and maintenance of a cable system.

One such example of this approach can be found in the project to install the Hibernia Express trans-Atlantic cable in 2015. This project put significant effort into clearing the designated route of 86 different instances where out of service cables crossed the new cable route. The physical effort involved extended to four cable laying vessels being used to complete the route clearance and pre-lay grapnel work over a total of 145 days [4].

Such effort and expenditure would suggest that there are clear benefits to new systems of recovering and clearing proven submarine cable routes in a responsible, managed way.

Recovery of out of service cables can also reduce the inherent issues associated with choke points or narrows where the topographical characteristics of an area can restrict a cable corridor. Removal of redundant systems will maximise the usable space available to new systems in these circumstances.

In addition, the demands of the blue economy and renewable energy has transformed projected utilisation of coastal states territorial water resources and when commitments to environmental protection are included, it becomes evident that industries are facing marine spatial planning restrictions. The ever-increasing influence of sustainable environmental management techniques will make it necessary to embrace or maybe even mandate out of service cable recovery post system decommissioning.

3. COMPLIANCE AND LICENSING REQUIREMENTS

Within a number of jurisdictions, licencing requirements place recovery obligations on subsea cables prior to entering service, after a prescribed time period or when withdrawn from service. There is significant variance in coastal states requirements in this regard; it is beyond the scope of this document to discuss this situation in detail however, requirements range from territorial waters (typically up to 3 or up to 12 nm); the limit of the EEZ or in extremis all submarine cable manufactured by a state in the High Seas.

4. SPARE CABLE RESOURCES

Submarine Cable recovery from out of service cable systems has always been a way of economic acquisition of suitable cable types, for a variety of purposes, as well as recovering landings and to secure cable routes. When cable recovery is for re-lay or re-engineering it is important that the recovery vessel is able to preserve and maintain all requirements of the cable marine handling instructions and that data associated with recovery is provided to the client when the cable is discharged, transferred or re-laid.

5. CABLE RECOVERY AND PLANNING OPERATIONS

5.1 Ownership

In order to secure the rights to recover an out of service cable system it is first necessary to obtain ownership of the asset concerned. In many cases there are a limited number of parties linked to a cable system and in these cases securing an agreement to transfer ownership is relatively straight forward.

As cable technology has developed over time the associated costs of installing a system also increased meaning that to share exposure to risk and to secure access to new systems, more complicated ownership structures developed. In some cases, a cable construction and maintenance agreement can include multiple tens of parties and in these cases securing agreement to transfer an asset can be more of a challenge.

As a critical first step, securing ownership of an asset is key and this means that cable owners will receive payment for assets that have been long depreciated.

Owners also lose the insurance liability for these cables as these obligations are transferred with the assets themselves.

5.2 Recovery planning

Cable recovery planning activities start with the use of accurate charts and route position list data identifying the position of the cable recovery target and the other systems, live and out of service, encountered on this route.

Recovery planning considerations make specific use of the ICPC Recommendations for Management of Redundant and Out of Service Cables [5] and Cable Routing and Reporting [6] as the basis of any planning activities.

Specifically, the following principles are applied;

Where a live cable system crosses a recovery target, the cable will be cut at 5 x water depth (WD) from the live cable crossing, assuming the crossing angle is between 45 and 90 degrees. Recovery activities recommence 5 x WD after the crossing.

Where cables run in parallel, or very acute angles, recovery activities are suspended where a live cable system is 3 x WD from the recovery target. Recovery operations only recommence where the live cable in parallel diverges from the recovery target by 3 x WD or more.

These guiding principles ensure that live cable systems are treated with the utmost respect and that the core principle adopted in all recovery planning is the protection of these live systems.

In all recovery activities it is incumbent upon the recoveree to have adequate third party general liability and special operations insurance cover in place at all times.

5.3 Peer review

Once a cable recovery plan has been compiled this is then circulated to the industry for their information and review. Full and open communications are essential in order to ensure that all possible steps are taken to minimise risk for all stakeholders concerned.

In normal circumstances a minimum four-week review period is established before recovery operations commence.

Any issues or amendments highlighted as part of this review process are incorporated into the recovery planning document.

5.4 Recovery operations

Recovery operations under taken by SES are carried out using a modified freighter, designed to provide an effective, fit for purpose, cable recovery ship.

All necessary notifications are made to relevant NavArea authorities and notices to mariners are issued identifying the location and timings of recovery operations.

Cable recovery activities are managed using the ECDIS system to ensure that all operations conform to the final recovery plan that has been circulated for peer review and amended where necessary.

Throughout recovery operations and where owners of live cable systems have expressed they be kept informed of activity close to their cables, daily reports are circulated to all concerned parties.

Post recovery completion reports are forwarded to original cable Owners and GIS managers to enable them to update safety systems such as KIS-ORCA or similar.

5.5 The physical impact of recovery operations

Companies operating in the recovery and recycling arena will need to work with regulatory and environmental bodies to build the necessary data to show cable recovery has no more environmental impact than cable installation. This will encourage the necessary safeguards to be put in place to ensure sensitive scientific or reference sites are not degraded by any such marine operations.

Cable recovery work involves the use of cutting and holding grapnels which have a limited physical impact on the seabed where they are deployed. A flatfish cutting grapnel has a blade approx. 5 cm thick which penetrates some 75 cm into the seabed with a surface plate which is approx. 50 cm wide. Gifford chains are approx. 20 cm wide and are designed to remain on the surface they are being deployed over.

Depending on the topography and geology of the geographical area these grapnels are used in, there is evidence to suggest that the scarring effect of these tools is limited and short lived, seabed mobility having the potential to naturally return the affected seabed to its pre-grapnel natural state [7].

Recovery of submarine cable itself, even if buried, is a short lived event.

6. REPEATERS, EQUALISERS AND OTHER SUBMERGED PLANT

As part of recovery operations, submerged plant including a number of repeaters and equalisers are recovered from the sea floor.

Modern fibre optic cables employ superior technologies when it comes to protecting submerged plant. Repeater and equaliser technology incorporated in coaxial and early fibre optic cable systems included surge arrestors designed to protect the circuits from any spikes in electrical charge. These units were cathode tubes which incorporated a small amount of radioactive material used to ‘prime’ the tube and minimise the statistical delay time [8].

The type of radioactive material used and the amount incorporated varied between manufacturers. The number of surge arrestors used in each repeater varied between manufacturer and technology. In most coaxial repeaters there are 5 or 6 surge arrestors per repeater. Early fibre era repeaters incorporated up to 3 surge arrestors.

All the repeaters and equalisers recovered from these cable systems are dis-mantled and the cathode tubes containing the radioactive materials are extracted and disposed of under license by authorised radiation remediation specialists.

7. MATERIALS RECYCLING

Submarine cables are designed to be left in situ for their operational lives, in most cases 25 years. This means that the quality of the materials used in their construction and the consistency of these materials is of the highest standard.

Recovered coaxial and fibre optic submarine cables therefore offer a very high degree of recyclability with, in most cases, 100% of the materials they comprise being re-introduced into the global supply chain. The recycling of these materials also offers significant benefits from an environmental perspective.

8. EMISSIONS

The differences in energy requirements to produce virgin materials equivalent to those recovered and recycled from submarine cables are summarised below;

Emissions comparison							
		Steel [10]	**LDPE [11 & 12]**	**HDPE [11 & 12]**	**CU [13]**	**Al [14]**	**Plastic Tape [15]**
Virgin Material	GJ/MT	23	73.1	89.8	33	212	88.55
KWH Equivalent	1 GJ = 277.78 KWH	6388.94	20305.72	24944.64	9166.74	58889.36	24597.42
	CO2e/kWh=0.480KG	3.07	9.75	11.97	4.40	28.27	11.81
		Steel	**LDPE**	**HDPE**	**CU**	**Al**	**Plastic Tape**
Recycled Material;	GJ/MT	9.7	26.56	24.29	4.4	17.5	26.56
	1 GJ = 277.78 KWH	2694.47	7377.84	6747.28	1222.23	4861.15	7377.84
	CO2e/kWh=0.480KG	1.29	3.54	3.24	0.59	2.33	3.54
CO2 Saving Per MT Virgin/Recycled		1.77	6.21	8.73	3.81	25.93	8.27
Percentage Difference		57.83%	63.67%	72.95%	86.67%	91.75%	70.01%

Table 1: Emissions Comparison – Virgin Feedstock v Recycled Cable

The approach we will take is to compare relative energy requirements for materials production from virgin feedstock and recycled submarine cables.

Carbon dioxide emissions per kilowatt hour (KWH) produced vary across the worlds economies as follows [9].

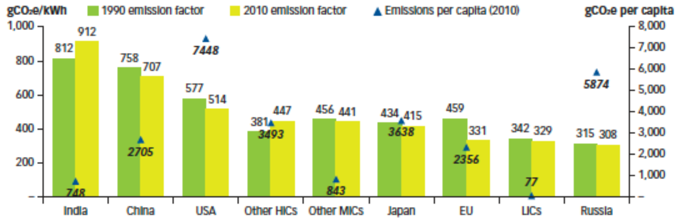

Figure 1: Changes in CO2 Footprint of Energy Generation

Sources: IEA 2012a and 2012c.

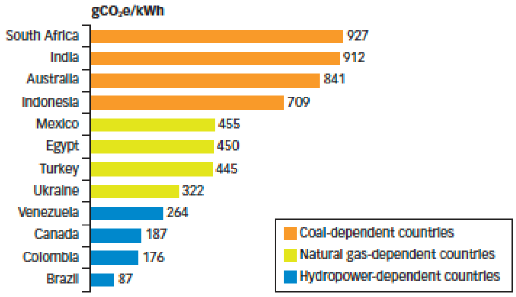

Figure 2: gCO2e/kWh by Country

For the purposes of this comparison we shall adopt a world average global emission factor of 480 gCO2e/kWh.

Using this emission factor we can therefore make the following comparison;

When these figures for equivalent emissions savings are used to calculate the recycling benefit of a single 2000 km 1.5" coaxial cable system the following results are possible.

		Steel	LDPE	HDPE	CU	Al	Plastic Tape
Equivalent savings 2000 KM of 1.5" coaxial cable		1033.88	12558.19	6017.01	631.26	8144.41	19.87
Recovery Vessel Emissions	640.6 Metric Tonnes						

Table 2: Equivalent Emissions Savings from 2000 KM of recycled 1.5" coaxial cable

A total of 27,764 metric tonnes of equivalent CO2 savings.

When it comes to sustainability reporting it is clear that recovering and recycling out of service submarine cables can make a significant contribution to the environmental performance of cable owners.

9. CABLE RECOVERY ANOMALIES

With increasing activity in cable recovery operations a limited number of unexpected anomalies have been encountered during recovery operations, particularly in terms of materials recovered along with the cable. Some examples of this are as follows;

1. Off the coast if West Africa approximately 5 cubic metres of plastic nets, ropes and other plastic waste was recovered which had wrapped itself around the main cable line being recovered.

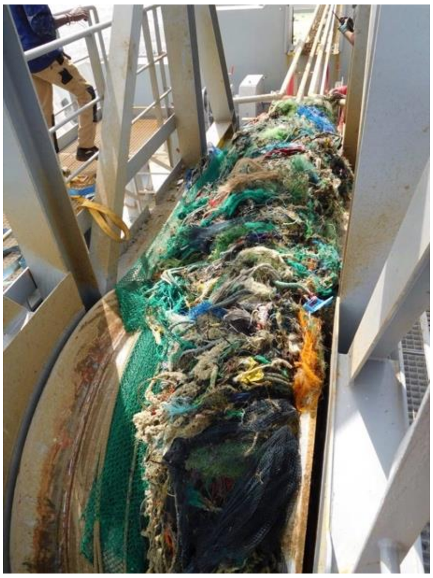

Figure 3: Plastic Material Recovered with Coaxial Cable

2. Off the coast of Western Europe cable was recovered which had somehow become a tangled mass.

Figure 4: Tangled Coaxial Cable

3. In the mid Atlantic a section a shredded cable was recovered wrapped around the main cable line.

Figure 5: Stripped Cable Waste Recovered with Coaxial Cable

In isolation these examples are minor in terms of the volumes of materials removed along with the cable recovered. As an industry there is limited knowledge of these types of instances and the frequency with which they occur. There is perhaps an opportunity to accurately record these types of anomaly in order to better understand their frequency and potential impact on the submarine environment.

10. CONCLUSION

For a number of years now companies have successfully and safely recovered out of service submarine cables from the World's oceans and seas. The processes followed in this activity have proven themselves to be fit for purpose, providing a safe, managed and controllable solution.

Since 1850, some three million KM of submarine cable has been deployed in the marine environment with approximately 66% of this being out of service and remaining in situ. This represents a significant resource which could otherwise be recovered and recycled.

Our planet is a finite resource and todays focus on global citizenship is increasing the pressure on corporations to adopt a proactive approach to developing the circular economy. Governments across the globe are continually reviewing and developing the regulations imposed in their jurisdictions now making cable recovery the final part of a systems life cycle. Recovering and recycling out of service submarine cables is a clear opportunity for cable owners to actively demonstrate their commitment to future generations and for a variety of other reasons;

- Generate revenues for cable owners from depreciated assets.
- Transfer of assets transfers the associated liability.
- Recovery of cable meets a variety of jurisdictional requirements.
- Recovery of cable for re-use is economically viable.
- Removal of redundant systems opens up pre-used, proven routes to new systems.
- The removal of old systems opens up choke points.
- The process removes hazardous materials from the submarine environment.
- The process returns valuable materials into the global economy.
- Recycling materials generates significantly less greenhouse gases than virgin production.

As this paper has hopefully demonstrated, cable recovery is a viable proposition which complements and supports the submarine cable industry.

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