RE-INSTALLATION OF RECOVERED SUBMARINE CABLES; CASE HISTORIES OF SUCCESS

Chris Willey,Philip J. Footman Williams,Paco Rego,Javier de la Cruz

cwilley@tycotelecom.com , pfootman@tycotelecom.com , frego@tycotelecom.com , jdelacruz@tycotelecom.com

Tyco Telecommunications (US) Inc.

Abstract: There have been several recent projects where recovered out-of-service cables have been redeployed for commercial or scientific use. This paper looks at several of these recent cases, including a case in which telecommunication cable systems have been constructed out of unused spares inventory. This paper will discuss both the feasibility analysis stage as well as the operational phase of chosen projects. The parameters and factors that influence the decision whether to recover and re-use an out-of-service cable, to construct a cable system from existing unused spares inventory or to build a new cable system will be discussed. A number of trade-off parameters must be considered when determining feasibility to build new or reuse, such as: decommissioned cables availability, cable recovery and installation relative locations, optical architecture, cable condition, permits and regulations, willingness of owners to donate or sell the decommissioned cable, available recovery vessels, willingness of installers to provide warranties, comparative cost of new cable, life expectancy of the new system, maintenance etc. These parameters change frequently i.e. considering current vessel dayrates from a year ago. Operational details will be discussed such as: cable recovery planning including implications of cable crossings, recovery in areas of cable congestion and traffic congestion, jointing and tanking planning of recovered cable for optimum deployment, testing and criteria for re-use, re-assembly of the “new” system and finally the re-installation. As a final analysis the use of decommissioned submarine telecommunications cables for scientific use will also be analyzed as this practice is now well established. There is no correct single recommendation for new build versus re-use since each application has unique requirements that will affect the trade-off. This paper will assess the parameters involved in the decision making process and the advantages and disadvantages in each unique application to assist decision makers.

1 INTRODUCTION

The initial phase of any new submarine cable project is the feasibility stage during which the technical and financial aspects must be considered. Both aspects are crucial to the success of the project, and with the potential for the re-use of de-commissioned cables instead of always having to build a new cable, this feasibility study must consider both cable supply alternatives.

There are a number of variable trade-off parameters that must be considered, such as: available cables nearing or in de-commission, their location relative to areas of scientific interest, the optical architecture, fiber type and fiber count of the de-commissioned system, their condition, permitting and regulatory requirements, willingness of the cable owners to donate or sell the out-of-service cable, availability of recovery vessels, willingness of installers to recover and relay cables and provide warranties, the cost and availability of new cable, the desired life of the new system, reliability and maintenance requirements.

These variable parameters change frequently. There is no correct, single recommendation for new build or re-use since each application has unique requirements that will affect the trade-off. The parameters will be reviewed and some case studies discussed in order to present an objective analysis of the question of whether to build a new system or to re-use an existing out-of-service cable.

There are also a number of fixed parameters that must be considered when evaluating the cost and feasibility of a new submarine cable system which apply to both new build and re-use cables. These include the initial desk top study and route survey, permitting, route and cable engineering, route clearance for buried sections, shore end construction and post lay inspection works, etc. These fixed parameters are well understood; however, in order to present a complete analysis they will be mentioned briefly in this paper.

2 DE-COMMISSIONED CABLES DISPOSITION

The number of submarine telecommunication cables being de-commissioned before the end of their design life is increasing as modern technology increases the capacity of the newer cables.

Table 1 below shows the numbers, lengths and type of fiber optic cables that have been de-commissioned in the various regions of the world :

Region	No. of Cables	Length kms	Comments
North Sea	8	2750	Armoured
Mediterranean	1	400	Armoured & Unarmoured
Atlantic/North Sea	9	40,000	Armoured & Unarmoured
Caribbean	2	4,500	Most Unarmoured
Eastern Pacific	4	27,500	Most Unarmoured
Western Pacific, Far East & Australasia	12	50,000	Most Unarmoured
Indian Ocean	0	0	N/A
TOTALS	36	125,150	Most unarmoured

Table 1: Amount of Available cables

The table indicates that there is a large amount of de-commissioned fibre optic cable lying on the seabed throught out the world, but an important parameter is the location of a desired cable relative to the area of commercial or scientific interest. Figure 1 below shows the distribution of the submarine telecommunications systems throughout the globe, both in-service and de-commissioned:

Fig. 1. Location of the World´s Submarine Cables

One factor in estimating the cost of a commercial or scientific submarine cable system is its location with reference to the de-commissioned cable to be recovered. The distribution of cables shown in Fig. 1 above shows that although there is a large amount of usable fiber optic cable on the seabed, the majority of cable lies in the northen hemisphere.

The proximity of a suitable de-commissioned cable to the work site is an important factor, especially as today´s high fuel costs and increasing vessel dayrates, make long ship transits an expensive option.

The main cable producing factories are situated in four of the seven continents, albeit also in the northen hemisphere and so it may well be as economical to manufacture new cable as opposed to recovering cable from a remote location.

Project feasibility must be on a case by case basis, and the location of cable is an important "trade-off" factor to be considered.

3 DE-COMMISSIONED CABLES - TYPE AND SUITABILITY

3.1 Fiber Type and Count

It is important that the optical architecture, fiber type and fiber count be considered when studying the feasibility of re-using a recovered de-commissioned system.

The cables that have been de-commissioned span the entire submarine fiber optic era and represent a catalogue of cable design and technological advance. The technology available in re-using cables varies extensively as indicated by the variety of cables that have been de-commissioned.

It is, therefore, important to evaluate the fiber type and count required as de-commissioned cables vary in type and suitability. Table 2 below illustrates the history of some de-commissioned cables and also shows the trend that the more recent the cable, the shorter the lifespan.

Cable	Region	Commission	De-Commission	In Service	Capacity
TAT-8	Atlantic	1988	2002	14 years	280 Mb/s
NPC	Pacific	1991	2004	13 years	420 Mb/s
BMP	China Sea	1992	2004	12 years	560 Mb/s
PacRim West	Pacific	1995	2005	10 years	560 Mb/s
Gemini North & South	Atlantic	1998/ 99	2005	7 years	55 Gb/s

Table 2 Type of Available cables

The earliest cable included in this analysis is the 1988 cable TAT-8, the first trans-Atlantic cable to be laid.

The earliest trans-Pacific cable was the NPC cable laid in 1991.

Another Pacific cable, PacRimWest, only lasted 10 years when it was de-commissioned in 2005; a section of this cable was recovered and relaid as a new telecommunications system from Australia to Papua New Guinea in 2006.

3.2 Armouring Type

The desk top study and route engineering process will determine the most appropriate method of cable protection to be used in areas vulnerable to external aggression. Another critical specification of the cable to be studied is the armouring compatability of recovered cable. Table 1 indicates that the amount of armoured cable that can be expected to be recovered is much less than unarmoured cable.

The feasibility study of a new cable system must consider the cable and fiber design of the de-commissioned system by studying the route position lists and straight line diagrams, in order to determine if the cable will be fit for purpose, and if it is in a suitable geographical location. The conclusion may be that a new build cable would be more appropriate and more cost effective.

4 DE-COMMISSIONED CABLES – CONDITION

The initial consideration in assessing the suitability of a de-commissioned cable for a "new" system is described in sections II and III above, namely the location, type and suitability of the cable. The next consideration is to assess the existing condition of the cable as it lies unused and possibly unmonitored on the seabed, and the condition that can be expected after the marine recovery process has been completed.

4.1 Condition on the seabed

A cable which is in service is monitored continuously for performance and for signs of deterioration or external damage. The fiber transmission, power supply (if a repeatered system), insulation and repeater components are monitored continuously to ensure that the entire seabed plant is operating within optimum and designed parameters.

A cable system is designed and engineered meticulously to ensure maximum performance and minimum disruption over its intended life time; however, remedial maintenance is required to maintain the condition of the cable on the seabed. Maintenance and repair may be necessary for a number of reasons as outlined below:

Component failure. This includes unplanned failure in repeater components and premature degradation of fibre or cable insulation. This is a rare occurrence because rigid manufacturing controls and component testing has eliminated 99.99% of these faults.

Third party aggression. The vast majority of this occurrs in waters of less than 1,500 metres and is the result of damage by fishing vessel gear or ships´ anchors. Cables are routed away from fishing grounds and ports, or steel wire armoured, or protected by iron articulated pipes, or buried, or a combination of all four, but can still be damaged. Cables in certain high risk areas are more susceptible to damage than others in low risk areas and during the feasibility study into the re-use of a de-commissioned cable, the fault history of the cable must be reviewed to assess its condition. This study should consider the number of repair joints in the cable as well as considering the number of third party "strikes" that may not have adversely affected the performance of the cable, passed undetected, although reducing the long term performance of the system.

Environmental aggression. This can occur in all water depths. Cables can be damaged by environmental and natural aggression such as submarine earthquakes and susbidence (as happened during the 2004 earthquake of Algeria in which 4 submarine cables were broken and much more recently, during the earthquake off Taiwan which severely disrupted communications throughout the Asian region, to the USA and Europe). Strong currents, rocks and submarine mountain ranges can also cause damage by chaffing and reducing the insulation of the cable. There have been a few recorded shark bite attacks, although these are isolated.

During the working lifetime of the cable, any deterioration in the condition of the cable caused by the above will be detected instantly and a repair undertaken. However, a de-commissioned cable may well not be monitored, and damage by any of the above causes could go undetected and the condition of the cable on the seabed will be unknown. This is a risk factor to be considered when comparing to a new build cable.

4.2 Condition after recovery

A cable is designed and manufactured within tight parameters to enable it to be stored, coiled and then installed on to the seabed safely and without any adverse effect on its performance. It is also designed to be recovered safely in the event of a repair. However, there are a number of factors than can adversely affect the cable during the recovery process and which should be considered when deciding on re-use or new build. These factors are descibed below:

Buried cable. A cable is buried in order to protect it from aggression, and the depth of burial varies according to the risk assesment. The depth of burial can vary from 1 metre to 3 metres under normal conditions, or up to 10 metres in exceptional conditions. A newly installed cable is laid into the bottom of an open cut trench which then in-fills naturally and the in-fill material then compacts so that the cable is fully incorporated into the seabed. The seabed sediment, however, is in a constant state of change due to sandwave movement, storm surge and submarine landslides, and, over time, the depth of burial of the cable is reduced and increased. A reduction in depth of cable burial will reduce cable recovery tension and will assist cable recovery operations, but an increased burial depth will produce increased cable recovery tension. An unexpected increase in burial depth, such as in an area of sandwaves, can produce sudden rises or spikes in recovery tension which could exceed the design working parameters of the cable and result in damage to the cable.

Cable crossings. The seabed is a congested place and, after some 150 years of laying submarine cables, the safest and most practical routes are recognised and actively sought after by all seabed users, including cable owners (telecommunication, power, scientific) and pipeline owners (oil, gas, water). Accordingly, the majority of cable have other cables or pipelines crossing over and on top of them, and in the case of older de-commissioned cables, there may be multiple crossings. The internationally recommended process of installing a cable crossing is intended to avoid damage to the crossed cable, but in the event of a de-commissioned cable, damage can sometimes occur. The process of recovering the de-commissioned cable at these crossings is to cut the cable and leave it on the seabed for an agreed distance in order to avoid disturbing the crossing cable. These factors can result in a loss of the amount of cable that can be recovered and additional joints that may affect performance and cost, and need to be considered in the trade-off analysis.

The trade-off between the re-use of recovered cable and the manufacture of new cable must take into account the fact that the condition of the de-commissioned cable will be unknown. The cable may not meet the system specifications or may include high costs of repairing and refurbishing. The fault history of the de-commissioned cable must be checked thoroughly and a risk assessment made prior to deciding to recover the cable.

5 PERMITTING AND REGULATORY

The jurisidiction of the permitting and regulatory authorities normally extends to the Economic Exclusion Zone (EEZ) of each country and the regulations differ in each country. The control of cables outside the EEZ is normally undertaken by the cable owner.

There are internationally approved procedures and recommendations for the removal of cables from the seabed to ensure that the seabed environment is not adversely affected by the process of removal, and an increasing number of countries impose strict conditions for the safe removal and disposal of cables. The main concern is to avoid disturbing marine vegetation in the area and to avoid leaving stray cable ends in the seabed that can damage fishing gear. It may also be necessary to place observers on board the recovery vessel to ensure that the regulations are followed.

In all submarine cable projects, the permitting and regulatory aspects are an increasingly critical factor, and for recovered cables, the additional time and resource must be factored in during the feasibility assessement. In some cases, the authorities may welcome the removal of a de-commissioned cable and may assist in the overall process, or, alternatively, they may disapprove and delay the project.

6 CABLE OWNER AGREEMENT

The agreement of the owner of the de-commissioned cable is, obviously, critical and the terms and conditions placed on the recovery must be negotiated. It is in the interest of the cable owner to divest the responsibility and liability of owning a de-commissioned cable on the seabed, and, indeed, many permitting authorities now require such cables to be removed in order to avoid paying a fee. However, the new cable owner will not want to acquire the ownership and liability of the entire de-commissioned cable, but only the portion of cable that will be re-used.

What terms the old cable owner will require of the recovering party, or new cable owner, may, in part, be determined by the applicable permitting and regulatory requirements, e.g., if the cable owner has a responsibility to remove the de-commissioned cable, he may wish to offload it as easily as possible at a low price; alternatively, if the owner has no outstanding cable liability, he may hold out for a high price.

It follows that the price of a de-commissioned cable will vary in the same way as the price for a new build cable will vary and all prices should be checked to obtain a full understanding of the options.

7 AVAILABILITY OF RECOVERY VESSELS

It is difficult to quantify the exact number of cableships in operation at any one time as the industry is still experiencing consolidation, ownership change and vessel disposal. In addition some vessels operate in the telecommunication, oil and power sectors, and alternate between one sector and the other, making it difficult to determine the final number with accuracy.

It is estimated that there are 45 vessels currently in operation around the globe with the capability to undertake submarine cable operations in one form or another. Of these, approximately 10 are the multi-sector, multi-purpose vessels discussed in the previous paragraph that are converted into cableships for specific projects.

The operations to be undertaken during traditional submarine operations are numerous and varied, but cable recovery and re-lay operations have additional specific requirements that may exclude some vessels.

The additional and critical requirements specific to cable recovery and re-use include:-

- large cable tank capacity to stow different types of recovered cable (armoured, unarmoured, scrap, spare)
- capability to turn over cable from tank to tank
- spacious centrecastle for handling repeaters and cable bights
- sufficient accommodation for the extra crew required as cable recovery will require additional men to load into the cabletanks
- jointing and testing personnel fully equiped to assemble the new system on board the vessel without having to offload into a depot ashore.

Based on the above requirements, 10 of the estimated 45 cable vessels are excluded as being unsuitable, thus reducing the number of cableships that fit the requirements to approximately 35. The next table compares the numbers of these suitable cableships :

Region	Length kms	Suitable Cable ships	Maintenance Cableships unavailable	Total C/Ships Available
North Sea	2750	4	2	2
Meditranean	400	4	2	2
Atlantic	40,000	10	4	6
Caribbean	4,500	2	0	2
Eastern Pacific	27,500	2	1	1
W.Pacific, Far East &Australasia	50,000	11	6	5
Indian Ocean	0	2	1	1
TOTALS	**125,150**	**35**	**16**	**19**

Table 3 Available cableships

Table 3 summarises the total estimated number of cableships suitable for cable recovery (column 3), those cableships contracted to maintenance duties and therefore considered unavailable for new system work (column 4), and in column 5 the resultant number of cableships that can be considered suitable for the work, and not contracted to maintenance duties.

Figure 2 below illustrates the general disposition of cableships around the globe, which, naturally, correspond to the main cable routes:

Fig. 2 Location of Cableships Incl. Maintenance Ships

From Table 3 and Fig.2, it can be seen that there are suitable cableships positioned worldwide, but care must be taken in ascertaining their suitability for the additional specific tasks involved in the recovery and re-lay of de-commissioned systems, as outlined in this section.

8 RELIABILITY AND WARRANTY

New build submarine cable systems are normally supplied and installed with a designed lifespan of 20+ years, and are accompanied by documented reliability forecasts to enable the cable owner to determine the lifetime performance of the system. In addition a new build cable is normally warrantied for an initial number of years when a manufacturing defect or fault will be rectified, free of charge, by the supplier.

A decision about the desired life, long term reliability and possible warranty of a new cable must be made when considering the use of a de-commissioned cable.

This may not be a simple task in the case of re-used cables as the unknown condition of the recovered cable, and its previous working life, make the prediction of future performance unreliable.

The costs associated with a cable repair or re-furbishment could be substantial, especially in a cable location remote from an available repair cableship, and this could eliminate any savings in the manufacture of a new cable. In this respect, the cost of maintenance must be factored in to a feasibility study, whether it is as part of an established Maintenance Association or as an ad-hoc repair philosophy.

These are vitally important factors in deciding whether to build new or to re-use.

9 NEW CABLE - COST AND AVAILABILITY

9.1 New Cable Availability

Submarine cable systems incorporate a wide variety of hardware such as the cable, repeaters and also in the case of scientific cables, hydrophones and sensors, subsea electronics as well as the dry plant and terrestrial links, There are a number of factories supplying these world wide. There are 9 factories and suppliers producing submarine cable (repeatered or unrepeatered) of which 2 are in the USA, 4 are in Europe and 3 are in the Far East / Australasia region, and again these are located along the main cable routes. These factories can be subdivided further into those specialising in repeatered cable and those specialising in repeaterless cable.

The telecommunciations industry as a whole has emerged from a sharp recession during which cable manufacturing capacity was reduced by closing some factories and by reducing the capacity of others. World-wide cable manufacturing capacity may now fall behind new demand expectations.

Availability and supply of new cable may now be subject to longer lead times from project feasibility studies to final delivery, for the foreseeable future.

9.2 New Cable Cost

The recession discussed in the previous paragraph resulted in drastic cost cutting throughout the industry to the extent that a number of factories closed and some companies ceased to trade. In addition, new lower cost products were introduced so that the overall cost of new cable systems fell substantially.

It seems that the market had become accustomed to low prices; however, this trend may not be realistic with highly increased signs in demand.

The trade-off between new build and re-use must consider increasing demand, changing ship availability and pricing etc.

10 TOTAL PROJECT COSTS

The sections above have reviewed those trade-off items that are specific to the the recovery of cables, but this section will take an overview of the entire project. There are a number of tasks that are common to all projects and whose costs are incurred irrespective if the cable is a new build or recovered. In some cases these common costs represent the majority of the project costs so that any cost differential between new or recovered cable becomes insignificant. This comparison must be undertaken on a project by project basis.

Table 4 below itemises the individual cost drivers of a typical project, indicating that the cost differential only occurs in one phase of many:

Cost Phase	New Build Cable	Re-Used Cable
Desk Top Study	Yes	Yes
Route Survey	Yes	Yes
Cable Manufacture	Yes	No
Cable Recovery	No	Yes
Route Clearance (Burial only)	Yes	Yes
Pre Lay Grap Run (Burial only)	Yes	Yes

Cost Phase	New Build Cable	Re-Used Cable
Shore end Cables	Yes	Yes – And/or pontential re-use of existing shore end cables
Marine Installation	Yes	Yes
Post Lay Works (Burial Only)	Yes	Yes
Project Management	Yes	Yes

Table 4: Different cost phases of a project

The trade-off analysis must, therefore, consider the whole project cost as the cost differential of new build / re-use may be a small percentage of the whole project cost.

11 CASE STUDIES

There are several cases being considered for the recovery and re-lay of telecommunications cables to be re-configured for filling in new routes in the Atlantic and Pacific. Two recoveries and re-lays have already been completed succesfully. There are also approximately 18 scientific cables in use in the Mediterranean, the North Atlantic, the Caribbean and the Pacific. Some of these cables are new build, some are recovered and re-used, and some are existing telecommunication cables that are also carrying commercial traffic.

The following examples illustrate that the decision to re-use a de-commissioned cable or to build a new cable must be taken on a case by case basis as the cost benefits vary according to the project.

11.1 Telecommunications Cable - Atlantic

In 2006 a telecommunications cable was required to be constructed from mainly recovered (all armoured) cable from another system.

The cable was recovered (> 500 kilometres) and re-laid without any undue issues regarding recovery, cable condition etc., despite all the cable being recovered from a previously ploughed system. The ancilliary costs (as outlined in table 4) were equivalent with two main differentials, these being the cost of cable recovery versus the cost of a new, factory-built cable. The other differential was that one shore end from the existing system could be left in-situ and only needed some slight re-configuration, thus avoiding shore end construction costs and all but eliminating any permit requirements in that particular location.

Cable re-conguration on the cableship was able to be carried out whilst at sea, while continuing the cable recovery, with only a few days required in port at the end of the recovery operation to complete final system assembly and carry out system performance tests before re-lay.

An analysis has shown that in this particular instance of cable to be re-used, due to the availability of a cableship in the area at the right time, the recovery cost of the cable to be re-used was much less than that of new build. Thus in this case, the solution was proven to be very cost effective and many of the risks were mitigated by careful planning, or did not occur, i.e. the cable condition on recovery was extremely good in all but a few isolated locations.

11.2 Telecommunications Cable - Mediterranean

In 2006 a case for a cable was under consideration for construction in the Mediterranean. In this instance, the case for a re-used cable against a new build was considered. The ancilliary costs (as outlined in table 4) were equivalent with the only differential being the cost of cable recovery versus the cost of new, factory-built cable.

An analysis has shown that the cost of options was all but equal, with a slight increase for the new build cable. However, the bonus of an extended warranty for the new cable and probable extended lifetime could be seen to outweigh the cost differential.

11.3 Scientific Cable - Atlantic

In 2004 a cable was laid succesfully between two islands in the Atlantic to serve an astronomical observatory.

This cable was a re-use cable which was assembled from three different de-commissioned cables, most of which were in storage in a cable depot as spare cable, although a short length of recovered cable was also used. The unique aspect of this cable was that it was assembled from different cable and fiber types.

The initial feasibility study was to determine that the cables and fibers would be compatible for jointing and transmission as the use of dissimilar cables was a bold concept. The cable tests indicated that the cables were suitable and the system was succesfully assembled from the different cables.

This cable proved to be an extremely cost effective solution in comparison with a new build cable, although it is stressed that the majority of cable was spare cable in pristine condition and not recovered cable, thus the project did not incur the costs of recovery or inherit the unknown cable condition.

12 SUMMARY

This paper discussed the various trade-off parameters to be considered when deciding on the feasibilty of a new build cable or the re-use of de-commissioned cable.

The following trade-off parameters must be considered:

- The geographical locations of the new and old cables;
- The type and suitability of the de-commissioned cable;
- The condition of the de-commissioned cable;
- Permitting and regulatory requirements in recovering cables;
- The terms and conditions agreed with the de-commissioned cable owner;
- Availability of recovery vessels;
- Reliability and Warranty of de-commissioned cables;
- The cost and availability of new cables;
- Total project costs.

In summary, the issue is “is new better and is second hand cheaper?”

There is no right or wrong answer as each scientific project will have its own requirements and specifications.

However, if there is a right and wrong answer, it will be right to review all the parameters discussed in this paper, and wrong to jump to pre-conceived conclusions.

13 REFERENCES

[1]The International Cable Protection Committee (ICPC) “Submarine Cables of the World”, February 2006.

[2] The International Cable Protection Committee (ICPC) “Cableships of the World”, April 2006.

[3] SubTelForum “The Cableships” Issue 20, January 2007