BUILDING SUBSEA OBSERVATORIES USING RE-DEPLOYED CABLES

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Abstract: The telecoms industry has established methods of successfully redeploying cables. These can now be applied to building subsea research observatories. This paper examines how experience gained in redeploying out of service telecom cables could be used to build observatories. The combination of established observatory technology with redeployed cable allows for significant cost savings as well as making possible systems that would otherwise be beyond budget limitations.

1. INTRODUCTION

In every oceanography research institute there are researchers whose thirst for knowledge far exceeds the funds available to make their research ambitions possible. Combining the latest reliable observatory technology with redeployed optically amplified telecom cables can reduce costs and make projects possible.

The backbone infrastructure of an undersea scientific observatory can be considered as a utility, supplying power and communications to the sea floor. The shore end and cable to the observatory are standard telecoms equipment. The most established undersea observatory technology is that used for tsunami early warning systems.

The cost models of telecoms and scientific observatories are very different: telecoms investors have a clear business plans with forecasted profits, moreover systems are built using loans or cash reserves. In the scientific world profits come in the form of new knowledge and financing is from of grants issued by government agencies. If a project exceeds the available grants it cannot go forward. Thus there is a need for observatory infrastructure at the lowest possible cost to make projects possible. Redeployed cables help meet this need.

2. REDEPLOYMENT BACKGROUND

The Gemini South cable was originally installed between Manasquan, New Jersey and Porthcurno in Cornwall during 1998. By 2004 it was no longer economic due to the installation of higher capacity cables. It was designed for 25 years use and despite being in good working order was taken out of service after only 6 years. These economics have caused a number of cables to be retired, [1] and presents an opportunity for cables to redeployed to areas of the world where they would be economic. One such example is the East-West cable between Jamaica, the Dominican Republic and Tortola, which was originally part of Gemini (Figure 1).

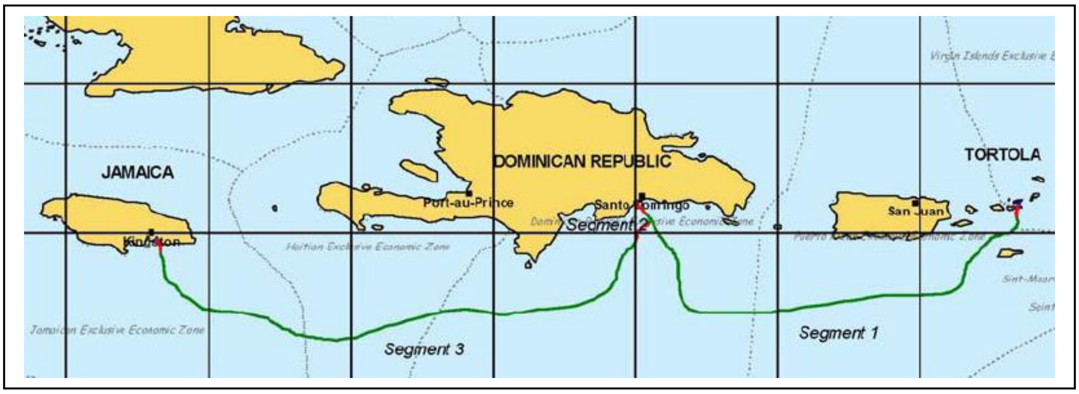

Figure 1: East – West cable system ©CWC plc

Due to their lower cost these cables are ideally suited for redeployment as observatories. Although systems vary redeployment cost savings are often substantial.

Redeployment is also environmentally beneficial. The global warming potential of a cable system invested in the form of raw materials, manufacture and installation is effectively sunk once it is taken out of service. This is about 20% of the total lifetime global warming potential of a system (the remaining 80% coming from operation and maintenance) [2], so it makes good sense to get as much benefit as possible from that original carbon investment. The exception to this would be carbon released due to ship fuel from a long transit from a donor system. However, a long transit would probably not be economic.

3. REDEPLOYMENT LESSONS

Experience has shown that the majority of cable and repeaters are as new when they are recovered. Occasionally repeater terminations and cable joints become damaged if they are recovered from burial. It is also normal to find some abraded cable, particularly in fishing areas. Therefore, extra cable and repeaters are generally recovered to ensure there is sufficient. This requires careful judgment as any excess will incur storage and disposal charges.

The cost savings for telecom system redeployment are considerable. From previous systems redeployments the total system cost is approximately 60% lower than a new system (Figure 2).

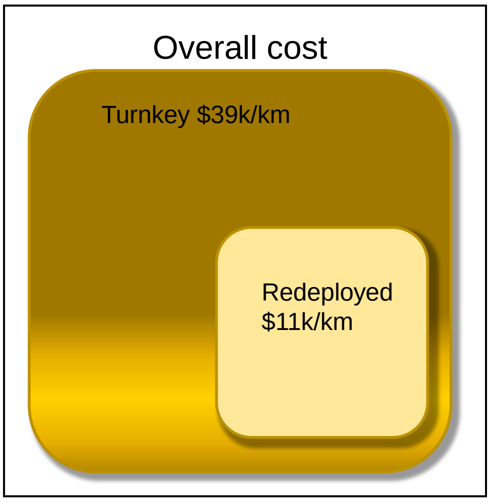

Figure 2: Area comparison of costs

The savings for observatories are not so dramatic as the observatory hardware is new. However the savings are still significant, and combined with the use of flexible node-based observatories, can bring a project within budget.

4. PROVEN RELIABILITY

Telecoms systems have a proven reliability. They are engineered for a 25-year life, and the 25th year can be considered as still being on the flat part of a standard reliability 'bathtub' curve. (Figure 3)

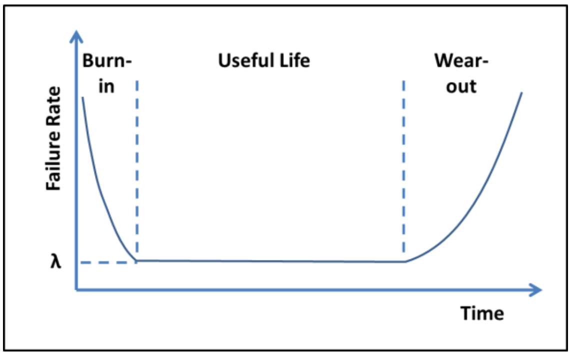

Figure 3: Typical 'bathtub' reliability curve

This high standard of engineering allows systems to be used at the end of and beyond their design life. The procedures for cable laying and recovery are also well proven. Experience has shown redeploying does not change the expected reliability.

It is realistic to consider much observatory data to be less critical than telecoms data. In most cases failure would cause instrument data not to be collected, delaying research. Under the worst case missing data would mean that papers could not be written.

However for some cabled observatories reliability is of critical importance. There are people in Japan who owe their lives to ocean bottom earthquake and the tsunami early warning systems like DONET. The Fukushima nuclear accident of 2011 was the worst since Chernobyl but it could have been much worse. The early warning allowed reactors to be shut down before the being hit by the earthquake and overwhelmed by the wave.

There is therefore good reason to engineer observatories to the highest standard, and less critical applications can take advantage of this engineering.

Scientists and universities do not usually have the expertise to bring together everything needed to build an observatory. The report recommending closure of the DUMAND observatory contained the following criticism: "*The universal sense was that the leadership of the project operates in a freewheeling style that is the antithesis of careful planning and quality assurance and control. This fatal failure was laid squarely on the project leadership, whose managerial skills and commitment to the project were strongly deprecated.*" [3].

This is clearly an extreme case and it is doubtful that given this warning from history any future observatory project would make the same mistakes. It does however highlight the need for technically competent project leadership such as offered by telecoms industry system suppliers and service providers. It is also an extreme example of the difference in culture between academia and industry.

5. CHANGE OF CULTURE

This cultural difference between academic institutions and telecoms customers must be understood by suppliers to get the best outcome for a project.

Academic budgets are smaller. The 'profits' of an observatory are knowledge without a direct cash value and as such gaining the initial investment is often more difficult. An observatory with a lower day-one cost but with many options for future upgrades is an advantage, as academic funding is often released in phases.

Timescales are also longer. A proposal to build a neutrino observatory forming a 1-km cube array of detectors in the Mediterranean has now been under discussion for more than 9 years – more than the operational life of some telecom systems. With scientific research there is also no guarantee of success. The model for this 1-km cube observatory is the IceCube observatory at the South Pole. Although it started operation in 2005 and reached full operation in 2010 it has not yet detected large numbers of extra-terrestrial neutrinos. While the performance of bespoke scientific instruments may not be guaranteed, the backbone architecture of the observatory must be reliable.

Team structures. Academic researchers are usually world experts in their narrow subject, working in small teams with other similar experts. Typically they will have a wide range of general skills and able to find creative solutions to solve problems on a limited budget. Many problems will require bespoke designs and are individually crafted. Telecom engineers by contrast tend to work in larger teams of highly specialized experts in the various disciplines required. Engineering follows a clearly defined development process with the final product qualified to a very high level, then industrialized, and manufactured in a quality controlled environment.

The combination of telecoms-grade standard infrastructure with easy and flexible connection to custom-designed science experiments allows for the best of both disciplines.

Attitudes to risk. Telecom customers want cables to take safe routes. Academics need to visit places of interest such as volcanos, smokers, cliffs, deeps and sea mounts. Care is needed to ensure that the observatory backbone is secure while allowing experiments to be close to dangerous locations. The more vulnerable parts of the system must be serviceable using a research vessel in order to reduce costs (Figure 4).

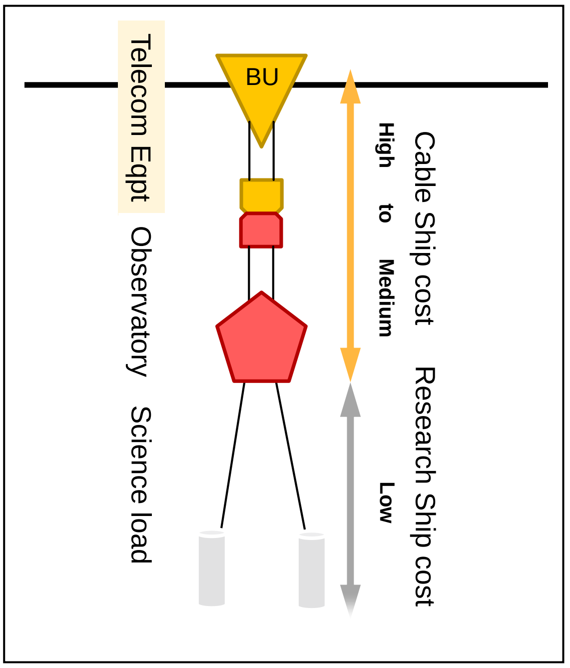

Figure 4: Relative ship cost of maintenance for different parts of the system

Project scopes also differ between the cultures. To build a telecoms cable a group of operators and investors will come together with a clear objective to connect various locations. As the project progresses it is normal for branches to be added or deleted according to the requirements of the various parties. The overall system configuration will only have small changes. Academics tend to have ambition beyond the available grants. Grant-issuing agencies under strict financial restraints tend to repeatedly de-scope projects. It is therefore in the researcher's interest to "go large" at the proposal stage and hope the final de-scoped project is not cut completely or made scientifically trivial. The challenge is to support the researchers throughout their de-scoping and changing requirements.

6. COST VS FUNCTIONALITY TRADE-OFFS

Today's telecoms purchasers are asking for systems capable of 100Gbps by 100 waves. They are also requesting pre-installed upgrade line cards for fast switch-on at a later date. Some are even requesting extra BUs to add in more stations in later phases. Academic customers by contrast may be forced by grant limitations to go with minimal technical solution for the lowest day-one cost. This may be at the expense of flexibility. It is possible to save costs by using non-switching fibre drop BUs in place of wave drop switching. The customer would have to accept that future upgrade costs may be higher or limited as a result.

Redeployed systems have the greatest cost advantage for longer reaches from shore as cable and submerged plant forms a greater proportion of the total cost. It is also advantageous where the scientific research may indicate new targets, allowing extending at significantly lower cost.

Some cabled observatories such as those designed for tsunami and earthquake detection have a well-defined public safety objective, requiring no change of use during their lifetimes. In such cases a fixed configuration of sensors is appropriate. In more generic scientific applications, a node-based system is required, where individual experiments can be attached to a common platform according to evolving scientific need.

An example of a node-based observatory is shown in Figure 5. In such a case, wet mate connectors are used to allow new equipment to be attached or removed as required. Multiple scientific objectives can be pursued simultaneously, perhaps by different institutions, as long the experiments do not mutually interfere.

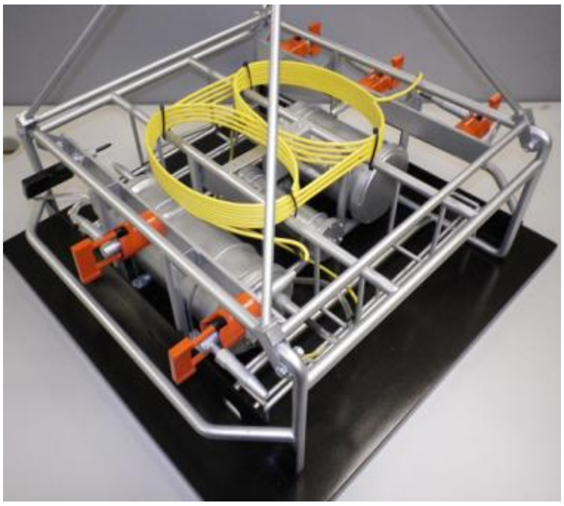

Figure 5: Ocean floor science node (MACHO System, Taiwan Central Weather Bureau)

Once the backbone cable and nodes are installed on the sea bed, smaller vessels deploying ROVs can carry out routine work on the observatory, keeping operating costs to a minimum.

Figure 6 illustrates the trade-offs and applications of various types of cabled observatory.

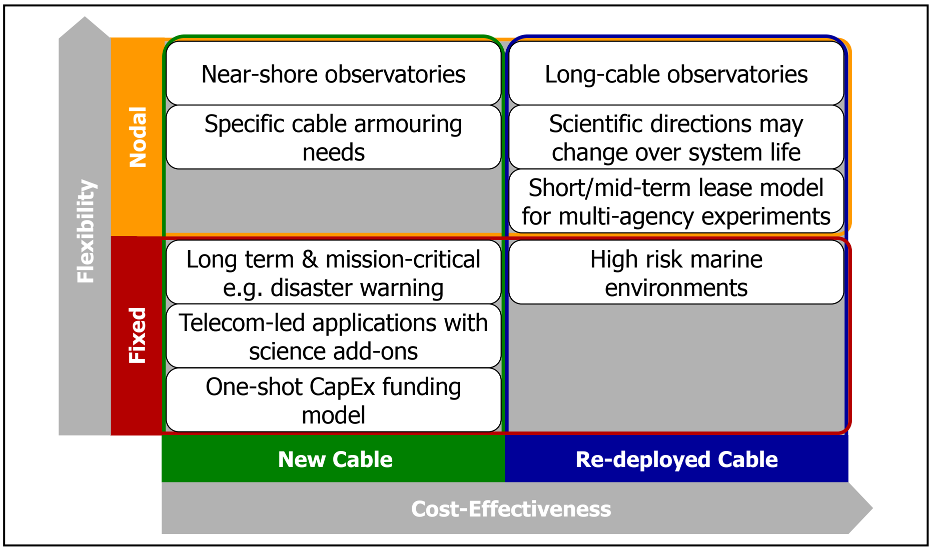

Figure 6: Relative cost effectiveness and flexibility

7. REDEPLOYMENT COST ADVANTAGES

The cost breakdown between the various parts of a typical redeployed and turnkey project shows the advantages (Figure 7)

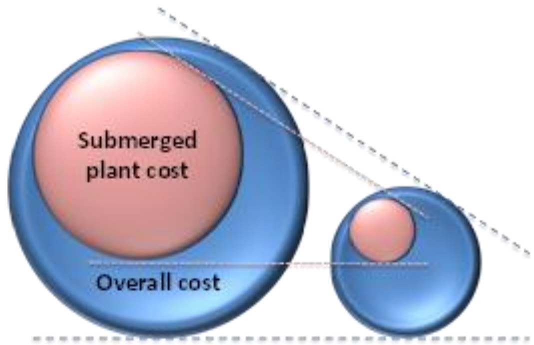

Figure 8: Relative cost of turnkey vs. redeployed cables by area

Marine costs increase as redeployment requires more ship time. This increase is more than compensated for by the large savings in the cost of submerged plant.

8. OUTLINE SPECIFICATION

Many researchers are competent to design instruments using basic electronics but would not be able to design using more complex telecoms protocol equipment. It would also be time consuming for them to write the complex software that normally controls such equipment.

In order to reduce costs for the researcher an observatory node should be able to support a variety of interfaces from the simple analogue to RS232c, RS422, RS488 and to more complex high bandwidth interfaces such as STM-1 for high definition video. There are some researchers who need high power levels of several kilowatts but for the majority of cases a few tens of watts are sufficient. Keeping the total node power under 500W and individual experiments under 40-45W is a useful way of reducing cost. It is easy to write a specification to cover the maximum possible requirements but this inevitably leads to higher costs.

9. CONCLUSIONS

We conclude that the use of redeployed submarine cables in subsea observatories – particularly those based on node-based platforms – brings a wealth of advantages in academic projects where budgets are restricted and where scientific objectives may evolve over the life of the system.

We also point out that although the differing cultures of academia and the telecom industry bring challenges in realizing cabled observatory projects, there are synergies to be found which ultimately make the realization of those scientific objectives a more likely prospect.

10. ACKNOWLEDGMENTS

With thanks to Cable & Wireless Communications plc for permission to use this material

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