SubOptic2019 TO THE BEACH AND BEYOND
RETHINKING GLOBAL NETWORKS

AN INDUSTRY UPDATE ON CABLE PROTECTION: ADVANCES IN TECHNOLOGY, EQUIPMENT, AND METHODS

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Abstract: Burial remains the most cost-effective method of cable protection. Successful burial is a result of a holistic approach towards risk assessment, route planning, hydrographic survey, and burial feasibility studies (BFS). The BFS allows for the selection of optimal plow and remotely operated vehicle (ROV) cable burial tools and outlines their operation to ensure cables are successfully buried, while simultaneously managing cable, equipment, and crew safety. New higher horsepower trenching ROVs and larger, more capable plows have been successful at achieving consistent burial in a range of soils, and in resolving special installation challenges. These challenges include dense sand, hard consolidated seabeds, and deeper water depths. Special operational considerations are given to plowing steep slopes to extend burial beyond the continental shelf, in sand waves, and in boulder fields. The overall program of plow, ROV, umbilical, control systems, winch, and A-frame maintenance are all crucial to a successful burial project. Advances in electronics and sensor technology continue to enhance subsea operations. This paper describes the many elements required for a successful burial program and provides updates on advances relevant to burial operations.

1. INTRODUCTION AND OVERVIEW OF ELEMENTS IMPORTANT TO CABLE PROTECTION

Data shows that submarine cables protected by appropriate burial into the seabed have a significantly reduced risk of damage from fishing and anchoring, which cause over 80% of all cable faults [1]. Burial also continues to be the most cost-effective form of cable protection. A focus on cable protection is essential to ensure overall system reliability. In this paper, we provide an update on the elements required for successful burial and cable protection; what remains the same, and what new advances have resulted in improved protection. Paying special attention to seabed surveys, data collection tools and procedures all pays dividends when developing the burial feasibility study (BFS) used to plan plow and ROV burial operations. The degree to which the actual burial achieved matches the burial prediction is a metric of success. This metric, which is maintained on all projects, provides a performance baseline for our tools in a variety of seabed soil types and is then used to predict burial on future projects.

2. RISK ASSESSMENT AND ROUTE PLANNING

Risk assessment should start with a thorough examination of previous operations in the area to help identify hazards, effective methods of installation and protection. This risk assessment is included in a robust desktop study, which also focuses on the current understanding of hazards. In most regions of the world, fishing and anchoring are the activities with the highest risk to a cable system, though some regions will have additional, more local concerns.

We find that plow target burial from 1.5m to 2m continues to provide adequate cable protection against risks endemic to the US and Europe, where the seabed is comprised largely of consolidated and dense, sandy sediments. However, in regions of Asia, up to 3m burial is targeted where fishing risk penetrates deeper in the soft seabed.

The use of updated, publicly available, commercial and proprietary databases will provide invaluable information that can help avoid or mitigate interaction with other seabed users.

An early notification effort to all crossed entities such as cables or pipelines will help avoid costly reroutes later and can help maximize burial by identifying the best tool and how it can be used most efficiently.

Well targeted meetings with relevant authorities during site visits help reinforce information from databases. In many instances these meetings fill in gaps where electronic information is lacking or incomplete.

A working group that includes the owner of the proposed system, the installer's route engineers and other key personnel are the best forum to identify risks to the system. Together, they will fine tune the route, focusing on appropriate risk avoidance and efficient use of the burial tool. The outcome of this meeting is most effective when it is part of a collaborate effort.

3. SURVEY AND BURIAL ASSESSMENT

An integrated burial assessment uses all available data and tools to characterize the seabed conditions where the plow and ROV operate. This allows for the design of a route and burial program that maximizes tool performance, burial depth, and cable protection [2]. Surveys continue to rely on a proven suite of sonar and sampling gear that has become standard in the industry. A Multibeam Echo Sounder (MBES) of sufficient frequency, resolution and depth capability is used to resolve bathymetric features and slopes (max. water depth for burial is from 200m to 1500m; 1000m is typical). Side Scan Sonar (SSS) maps obstacles and seabed features, while backscatter data is interpreted to infer seabed composition in the surface layer. An acoustic Sub Bottom Profiler (SBP) penetrates the seabed to assess layering and composition at least 2m to 3m into the substrate along the survey track lines. Seabed samplings (gravity cores and grab samples) provide ground truthing of the geologist's interpretations. These are discrete samples spaced often enough to resolve changes in the seabed composition along the route and transverse to the route. Cone Penetrometer Tests (CPTs), when placed strategically, provide needed ground truthing.

The result of the BFS is a detailed document which outlines the expected burial results along the cable route. Achieving target burial is not always possible based on many factors including seabed geomorphology and other environmental factors. Areas where burial is not predicted to achieve full target depth are identified. Risks are then discussed with all parties involved to determine the best available course of action to maximize cable protection.

4. BURIAL TOOL SELECTION AND CAPABILITIES

Burial tool selection is a combination of many factors including external aggression risk, seabed composition and contractual requirements. Preliminary tool selection takes place following the desktop study, when regional risks and target burial requirements can be evaluated. Final tool selection is then validated during the BFS based on pre-lay survey results. High risk areas with target burial requirements of 2m or greater will utilize larger, more robust plow systems. Examples include the Sea Stallion 3 or MD-3 plow systems, each capable of up to 3m burial. Lower risk areas with less stringent burial requirements targeting between 1m and 1.5m may utilize smaller plow designs. Having a versatile vehicle toolbox allows operators the flexibility necessary to meet contractual burial requirements across a wide range of risk profiles and geographic locations.

Plow systems have steadily increased in size since the early 2000s and that trend has continued through 2019 [3,4]. Early plow systems in the 1970s buried cable to a maximum depth of 24-inchs and for many years, the 1.5m plow was the standard in the Atlantic and Eastern Pacific. However, more demanding burial requirements, particularly in Asia and other regions with high-risk fishing activity, have seen a push toward larger, more capable high tow force plow systems.

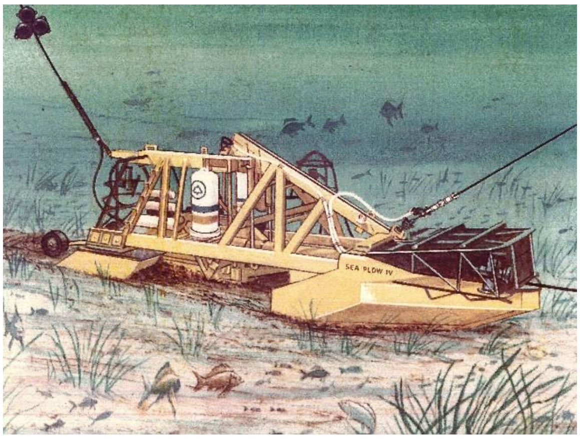

Figure 1: Early Plow System - Sea Plow IV

Vessel tow winch systems have steadily increased in capability to match these larger 3m capable tools. Plow jetting systems continue to have a place in the market and can help reduce the overall tow tension while plowing, primarily in shallow coastal regions where sand is traditionally more prevalent.

The basic plow form has seen little change since the MD-3 and Sea Stallion 3 designs entered the market. However, plow designs continue to evolve and build on well-established concepts. The Sea Stallion 3 MkII Plow has, for example, retained the durability and aggressive share design that its predecessor is well known for, while making improvements to the cable loading process, operator interface and control architecture. With advances in modern control systems come improved diagnostic features, which allow pilots and technicians to more easily identify and diagnose system faults and reduce overall project downtime.

Figure 2: Modern 3m Plow System - Sea Stallion 3 MkII

ROV trenching designs have also seen a steady increase in horsepower (HP) throughout the last decade, much of which is being driven by cross-over from adjacent markets such as offshore wind and Oil and Gas (O&G). With additional HP comes the benefit of increased burial productivity and the potential for deeper burial, but the benefits come at a price. Upfront capital expenditures (CapEx) and long-term running costs increase with vehicle size and HP. The inflection point between productivity savings and additional operating costs can be challenging to predict. With increased capability often comes increased expectation and these, along with other factors, can erode expected productivity gains, leaving only increased cost. When procuring new vehicle systems, operators must look holistically at the telecom industry to determine what future tools are required to meet burial requirements and customer expectations on cost. A balance must be found between tool HP and total project cost without sacrificing the long-term protection of the cable system.

One way to mitigate the choice between high HP and cost is to develop a vehicle system that captures the beneficial engineering trade-off between these competing forces. For many years, the 300kW (400HP) cable maintenance ROV has been well accepted within the telecom industry. It is powerful enough to bury telecom cable in demanding conditions, while still maintaining a manageable cost-effective deck footprint. With recent advances in subsea motor design comes the ability to increase vehicle HP within the 400HP frame. One such push for advancement has resulted in the development of the QT500 cable trenching ROV, a 500HP, 3-meter capable trenching system within a manageable vehicle size envelope. With a 25% HP increase, this vehicle captures the benefits of higher HP while also mitigating the increased operating and project costs associated with much larger vehicle systems.

5. SUBSEA SENSORS, TECHNOLOGY AND CONTROL SYSTEMS

Other advancements in subsea technology have helped drive productivity and meet customer expectations. In 2019, it is almost impossible to find a standard definition (SD) television, yet many vehicles in the subsea telecom cable industry still operate SD camera systems. Over the years, there were many arguments for not rushing to high definition (HD) systems, and at the time, given the upgrade costs, telecom operators may have had a point. While there was a need for HD in adjacent ROV industries, it was hard to justify the significant investment costs without a strong business need within subsea telecom. As HD becomes ubiquitous across broad consumer markets, the cost reduction from large-scale production has slowly filtered into the subsea industry, making costs more manageable. HD camera systems will undoubtedly become more prevalent on subsea telecom trenchers in the coming years as operators upgrade or replace ageing vehicle systems.

Real time multi-beam sonar systems are also starting to take hold throughout the general ROV industry and may be the most appealing advancement for subsea pilots. Free-flying work class systems operating near critical subsea structures were the first to readily embrace this technology. Operator

Figure 3: 500HP Trenching ROV - QT500

bleed-over between subsea energy and telecom has brought with it different perspectives and new technology recommendations. In telecom trenching, camera visibility typically lasts until the jetting pumps are engaged. Navigation is then managed through sonar, acoustic positioning, and cable detection systems. While traditional obstacle avoidance sonars remain the industry workhorse, the image refresh rate is less desirable compared to multi-beam systems, particularly when operating at high rates of turn or in dynamic situations. Real-time multi-beam sonars help mitigate these effects and allow for higher degrees of situational awareness when working near subsea cables or in poor visibility. Tasks like cable touchdown monitoring and final bite inspections will see the benefits of this technology immediately.

Subsea trenching gear can last decades, yet the electronics that control the operation of these vehicle systems changes rapidly as new technology develops. As a result, control systems are typically the first element of a plow or ROV system to become obsolete. For subsea trenching equipment with life spans routinely pushing greater than 20 years, many control components reach end-of-life or become difficult to support long before the remaining sub-systems. The trend in the trenching industry has been to move towards Programable Logic Controller (PLC) or industrial I/O; however, this does not fully eliminate the risk of obsolescence or dependency on vehicle manufacturers. Unlike mechanical or hydraulic elements of the ROV system, which can be upgraded or changed with minimal engineering effort, the control hardware is intimately linked with the control software, requiring significant investment to correct. This requires ROV operators to retain savvy support teams who routinely find creative ways to support legacy equipment, coupled with a strong roadmap for control system upgrades.

Cost is always a consideration and control system upgrades require significant capital. One way for operators to mitigate cost and complication is to build multiple control systems in tandem. In the case of Sea Stallion 3 (SS-1), an upgraded control system was built directly alongside the Sea Stallion 3 MkII (SS-4) newbuild, resulting in two identical control systems. While there were design differences between the two generations of plow systems, the new software and control hardware architectures became virtually identical. This allows SS-1 to benefit from the latest plow control architecture, while reducing upgrade costs, creating spare commonality across multiple systems and increasing operator familiarity across the plow fleet.

Figure 4: Modern Sea Stallion 3 Control System

6. CONCLUSIONS

The reliability and robustness of undersea telecom networks that power the internet will continue to be measured by how well the cable is protected from their greatest threats; anchoring and fishing. Burial of the cable into the seabed remains the most cost-effective form of protection and requires a fine attention to routing, seabed assessment, burial tool capability and selection. As described here, plow tools have grown significantly in size, weight and burial capability, where 3m is now the standard design for high risk areas. Meanwhile, ROV tools have also increased their burial capability while reducing risk with the addition of more power and new market surveillance equipment. A successful burial program will continue to focus on a holistic approach that evaluates the critical elements of cable installation discussed in this paper. The ultimate goal is to reduce risk to subsea cables and provide uninterrupted data to users around the world.

7. REFERENCES

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