WHAT NEXT FOR THE UNIVERSAL JOINT?

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ABSTRACT

The Universal Joint (UJ) is well established as a core industry technology for submarine telecommunications cables having its roots in the first optical cables systems, and has evolved as the optical cable technology has developed and grown. The emphasis placed on it by system owners, service providers and industry monitoring bodies demonstrates the significance and value it still provides to the industry. This stems from the availability of a common joint platform which permits freedom of choice for the system owner for its maintenance provider as the technology utilises a common set of parts, equipment and assembly methods facilitating efficient technology transfer and knowledge sharing within the industry wide pool of qualified jointing personnel.

This was established early in the 20 years of the subsea optical fibre telecommunications industry and continues to incorporate the changes to cable technology to an ever changing customer base of system owners, maintenance providers and system suppliers. Whilst that is all very well, we are approaching the position where it is appropriate to ask, what next? How should jointing move forward? What is the next technology leap? Closely aligned to this question, in our industry cycle of limited free cash, is the question of where should we target the investment of resource for maximum benefit and how shall it be funded?

This paper sets out the drivers that Global Marine Systems Limited (Global Marine) is seeing from its customers as a maintenance provider and end user of jointing technology; the innovations that have been and will be introduced by us to meet them and engage in discussion to determine what as a industry we should be doing next?

GLOBAL MARINE'S ROLE IN THE UNIVERSAL JOINT CONSORTIUM (UJC)

The primary purpose of the Universal Joint is the reliable re-instatement of single and/or multiple cable vendor optical systems and the construction of any Universal Joint is the culmination of much development, collaboration and investment within the industry. Global Marine makes its contribution to this industry standard technology in a number of areas and whole heartedly supports the Universal Joint concept as a key technology that benefits the industry as a whole.

As a maintenance provider Global Marine is an end user of the technology and offers much in the way of feedback as to its development and direction and seeks similar feedback from its customers.

As one of the founding member of the Universal Joint Consortium (UJC) it proactively challenges and collaborates with the other consortium members to provide UJ innovations and solutions to while preserving the key concept of universality and accessibility to the whole industry.

Global Marine is also a supplier of the technology with the provision of competitively priced piece part and tool kits, jointer training and cable qualifications. Hence it can be seen that the UJ is central to Global Marine's optical cable maintenance operations and its commitment to developing the concept further. For clarification the views expressed in this paper are those of Global Marine and not necessarily those of the UJC or its members.

RIGHT FIRST TIME vs. TIME REDUCTION vs. INVESTMENT or TIME, COST, QUALITY

In its current form the repeatered UJ has demonstrated itself as a very versatile and adaptive platform for interconnections between diverse optical cable designs, linking the pioneering and those of the foreseeable future. It has adapted to such challenges as hydrogen

management and loose tube cable technology while maintaining backward compatibility. As such it has, like cable designs, stabilised into a mature technology. In order to continue the improvements of a repeatable right first time joint construction, in the least overall assembly time then the challenge appears to be not with the development of the common platform which would require radical and fundamental change to bring about a significant benefit but with the equipment and processes external to it. It is here that investment, cost of improvement, will have the greatest impact, although it is interesting to speculate as to potential radical joint design.

INNOVATION CIRCLE

As alluded to earlier, the actual construction of the joint is only the area for developing, improving the overall UJ product and is the whole of the development, innovation cycle should be considered alongside the 'what next' question poised. The following is somewhat arbitrary breaking up the complete product development cycle into convenient headings, but there is much overlap between the adjourning 'phases' elucidated in the following description of each, giving possible directions for the UJ technology.

QUALIFICATION

The process of achieving formal qualification[1] of any new or modified cable design is in line with the ITU-T 976 standards and covers interconnection within the range of variants of a cable design and the full or partial interconnection to other cable designs as required. There should also be validation qualification in the event of a significant material or dimensional change to the cable, such as a change to the cable insulation. Here it is essential that cable manufacturers ensure the change will not affect the qualification status of the cable design to ensure full life in service. This also includes additions to the cable range, such as the inclusion of a heaver/lighter armour design, either by increasing wire count, diameter or hardness. There is a safety requirement for each design to demonstrate that the cable and joint can be recovered over the sheaves at the quoted maximum dynamic loads (i.e., NTTS) for the combination and that in straight pull at least 90% of the published UTS (or CBL)

The situation arises where early cable design has been superseded from manufacture and is no longer in maintained, operational cable systems. While it is the case that some decommissioned systems, using these able designs have been recovered and redeployed elsewhere, there is some merit in reviewing the current UJ qualification matrix of 700+ interconnections over 30+ cable designs and removing those cables and interconnections which are no longer applicable. This has benefit in training and kitting provision as simplification of the extensive construction documentation

TECHNOLOGY TRANSFER

Within the member companies of the Universal Joint Consortium there is access to the training schools that provide Jointer Training to the requirements of a common training standard. While the schools are operated independently of the UJC, under the processes of the parent UJC member company, the instructors have intra-company technology transfers whenever new cable is developed, or there are significant changes to tooling and/or processes. This ensures that the latest in jointing developments are taught in schools and that there is a frequent sharing of information. How the instruction is passed onto its own internal jointing personnel is a matter of best practice for each member of the UJCs particular situation with their maintenance contracts. Within Global Marine a dual system of shore and vessel based training is provided. After their initial training, each jointer is required to maintain and then demonstrate their competency. This is achieved by the upkeep of a jointing logbook to provide evidence of having completed either two operational or practice joints within the last 12 months and participation in a UJ jointing re-qualification programme. This course ensures skills are maintained and culminates in a written and practical assessment (i.e., complete a joint on an individual basis). All of the joints are then dissected to ensure conformity with the UJCM.

[1] M. Kordahi et al, " International Standards for Undersea Cable System Testing", SubOptic 2004, March '04 Monaco

There are three defined outcomes:

Pass: Joint completed in timescales. No inconsistencies, deviations from specifications or failure mechanisms identified from ongoing assessment and post-completion dissection.

Minor fail: Minor inconsistencies or concerns identified in; completed joint, processes followed or rate of work, that do not fall in the "Major fail" category defined below.

Major fail: Significant issues identified from ongoing assessment or post-completion dissection that would have resulted in lost time (through excessive rework) or potential failure during lifetime for a system joint or significant rate of work concerns (time constraints).

Dependent on the outcome above, the following course of action will be taken:

Pass: Jointer's qualification status revalidated, no further action required.

Minor fail: Immediate remedial training will be given in the areas in which deficiencies have been observed.

Following this remedial training, the candidates will undertake a mini-practical assessment that covers only these elements (not the full jointing exercise).

Major fail: Based on the deficiencies identified, the Training School shall develop a remedial training exercise for those assessed in this category.

Following this remedial training, the candidates will re-take the full practical assessment. If the candidate passes, their qualification status is revalidated, but with a 6-month time restriction attached. The candidate must return to the Training School to retake the full practical test before the full two-year accreditation is given.

Shore-based training, which includes all practical assessments, allows for training students both internal and external to the organisation to consistently high standards with no interruptions.

Training on vessels has the added benefit of guidance in the working environment, regular review of the jointing space and maintenance of equipment etc., but runs the risk of being interrupted due to operational requirements of the vessel.

PREPARATION

A central part of sustained jointing improvement and development is the regular review, familiarisation and practice of the skills learned and demonstrated during training. Similar attention is paid to the maintenance and use of tools and equipment. The recommended frequency and procedures for such equipment is given in the quarterly updated UJ explorer manual which is available by subscription from the UJC. This core 'document' also includes specification updates to the construction manuals, important safety and hazard warning information hazard, product update information such as the 'UJ bulletins'. All these should be reviewed prior to construction of a known repair joint, ideally with the construction of a practice joint build including the run through of the main and spare equipment and where possible the cable end preparation of the stock cable end prior to reaching the repair ground.

Close checking of the expected cables to be interconnected should be made to ensure that the correct End Specific Kits (ESK), Common Components Kits (CCK) kits and within shelf life Adhesive Kits are loaded. Knowledge of the fibre types to be spliced is also essential as is in 'qualification' jointers trained in the specific joint technology and ESK. This is often a complex task but can be managed well before its requirement with regular review, project management of each vessel and the maintenance agreement it serves. The use of a dedicated jointing record platform such as JADE[2] (Jointing Automated Documentation

[2] Phil Hart et al, Industry Reporting Tools: JADE (Jointing Automated Documentation Environment), SubOptic 2007, May '07

Environment) has significant benefits in checking the kitting provision as well as ensuring that the most current version of the construction manuals are available.

JOINT CONSTRUCTION

The JADE system also collates the comprehensive set of construction manuals into a single document which is bespoke and unique to each joint. Some time ago Global Marine introduced a system of joint reference that is indicated by each vessel so that the records of each joint can be consistently traced. Hence when using JADE a unique record is created that encapsulates the joint reference, system information, cable types, jointing personnel, calibration status and serial numbers of equipment and piece part kits used.

The format of the document is a storybook, reference style where, as the jointer is well trained and familiar with the technology, only a quick confirmation of the sequence, key dimensions, checks and measurement points is necessary. Each standardised section has a time stamp automatically assigned as it is started and completed. Global Marine has also introduced a system of 'Rapid Repair' techniques whereby after ergonomic review and organisation of the jointing team, a 'squad' system of seven jointers, led by a fleet jointing instructor, is focused into individual sub-process task with a maximum of five jointers working at any one time. This has reduced the average jointing time of recent, IPRS (Independent Performance Reporting Service)[3] analysed joints to approximately 9 hours, where previously the comparable jointing average time was approximately 13 hours[4]. Joint times of 7 hours or less have been regularly recorded. This has been achieved solely with the management of process and training of personnel in the method, and has not involved replacement or modification of any of the 'baseline' equipment.

The team do prepare a second, duplicate set of equipment should they be required. They also keep key spares, such the moulding thermocouples leads, close by. All of these changes, although individually not significant, when added together makes the process of jointing much swifter. Currently in development is a version of JADE that incorporates Global Marine's Power Grounding Unit (PGU) that provides warning of electrical current in the cables being linked. This allows the benefits to be applied to all joints although the safety aspects of such repairs remain paramount.

REPORTING, ANALYSIS & FEEDBACK

A critical part of the jointing process that is often discounted when assessing jointing times are the steps taken to measure the optical attenuation[5] at key stages of the jointing process. Cable Testing has perhaps received less attention where statistics are concerned. However the reworking of splices can greatly increase the overall jointing time and the testing time itself can affect and does contribute to the overall Repair Time.

Global Marine has continued to focus on the improvement of Testing Times towards the longer term objective of minimising the time taken to carry out measurements on the cable and fibres whilst, importantly, maintaining the QA checks that are necessary to ensure the integrity of the joint deployed.

Efficiencies in testing will yield considerable benefits in terms of the reduction in repair time, particularly for the case of high fibre count cables such as 24, 48, 96 and 192 fibre systems[6]. The introduction of a number of different tools and modified procedures is assisting in the improvement of Jointing Times. The latest assessments indicate that, where used, the correct equipment and procedures can significantly reduce the normal time spent testing during a cable repair. For example for a recent cable repair a figure of approximately 50% improvement has been demonstrated.

Other measures of the jointing process include checks of tensile elements to ensure safe

[3] Graham Marle, Reducing the cost of failure in submarine Cable repair Operations, Suboptic 2001, May '01

[4] IPRS, Shipboard Cable Jointing Report No.39, Section B, Page 6 2.3 Faster Jointing Times

[5] Dr Annette Linholm Colton et al, A field tool for the estimation of spice loss from one-way OTDR and statistical MFD values, Suboptic,2004, March '07

[6] Craig Beech et al, Future Shipboard Jointing for High Fibre Count Cables, Suboptic 2001, May 2001

deployment and recovery and inspection of the re-instated cable insulation to ensure the service performance over typically 25 years.

The final measure is of time, importantly lost or rework time, allowing comparison and monitoring between similar cables and develop the general trends within jointing.

Again a product such as JADE has significant value to add as it automatically prompts for the completion and recording of set measurement steps and details the time, with construction notes, for each stage in a standard format.

In current practice the hardcopy of records such as the spicing printout and x-ray plates are sent under sealed and logged envelope to a central archive for later analysis if required. The construction report is sent for the independent collation of jointing under IPRS and there is also analysed under the Global Marine Jointing Evaluation Form (JEF) where time lost is recorded under the following sections

- Spec Design
- Equipment
- Skill
- Work Environment
- Cable

for each vessel. The joint is given an individual joint number, which is used to track all data associated with that joint. Data recorded includes jointing time, rework time, jointer ID and system name

Global Marine receives feedback directly from the fleet during each repair and through the analysis of the JEF reports. It also studies the IPRS for the industry trends and to benchmark its own performance. For repairs outside of the Global Marine partnership feedback on the UJ products is encouraged directly to the UJC via the link on the website or to the consortium co-ordinators e-mail. In each piece part kit, there is also supplied and copy of the UJ explorer disc, a feedback form with can again be sent to the coordinator. The UJC also holds and encourages customers to participate in their regular customer forums.

INVESTMENT

The UJ is a time proven, established jointing platform that has widespread application in the optical telecommunications maintenance vessels. This is the strength of the product as it fulfils its 'universal' application role, radically reduces the complexity and cost of maintaining cables across the range of cable manufacture cables and employed systems. Simultaneously it makes changes of the large capital investment items such as the moulding and x-ray units expensive to replace. In the current market conditions development and investment in such large items are hard to be justified by a single company acting alone. Investment partnerships between system owners, providers and maintainers is a useful model to consider if a 'Universal Joint' concept is to continue without fragmenting into sub-sets which go against the defining principle of a single, standardised set of equipment and procedures that are consistent use and in training[7].

The development and introduction of some items have less resource burden as they are small in nature or developments of existing equipment and are regularly developed and introduced by the individual members guided by experience from their own maintenance footprint or from the various sources of feedback previously mentioned. Such innovations or developments are reviewed for suitability as 'UJ' product that the UJC authorises as being optional or fundamental to the technology.

RADICAL JOINT DESIGN

What is the next step of a 'Universal Joint' in its current form the jointing platform meets the functional requirements placed upon it and has been demonstrated that it can be constructed in under 7 hours of which a further 1 ~ 2 hours could be reduced with changes in the supporting equipment. This compares very favourably to joint designs that are designed specially for the cable manufacturer's cable which are not required to be 'universal' in application. There has long been suggested a 'plug and play' version of the joint using

[7] Joel Whitman, The Future of the Universal Joint Consortium, Suboptic 2007, May '07

wetmateable technology. Without a fundamental change of the way systems are constructed and repaired on the seabed, it is difficult to see an advantage being made as one end must always be recovered and terminated.

The ideal joint must be indistinguishable from the cable, no longer a rigid discontinuity. ‘In-line’ jointing has long been a goal for joint designers but is often hampered in the reliability of first time splicing or the management of long, flexible joint housings that have sufficient fibre slack for repeated splice attempts, and strength for deployment. But much has changed over 20 years of optical jointing and so maybe the time has indeed arrived to try again.