HOW FAST CAN AN UNDERSEA TELECOMMUNICATION SYSTEM UPGRADE BE IMPLEMENTED?

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Abstract: Network owners require high quality systems that meet their immediate needs, but many forward-looking purchasers of communications networks are also aware that in areas of burgeoning communications demands, their systems may require future capacity upgrades. As a result, they are seeking network upgrades in the shortest possible timeframe. Some are even searching for the same model of quick, plug-and-play upgrades available to personal computer users requiring a software upgrade. Given the complexity of undersea telecommunication systems, will these autonomous upgrades ever be possible? And if not, what can purchasers look for from their suppliers to shorten the time required for network upgrades?

1 INTRODUCTION

It is very difficult for network owners to predict their capacity needs for a given year, hence it is imperative that a network owner have the flexibility to be able to upgrade an undersea system in the shortest time possible and ensure that a sales opportunity is not missed. Suppliers have the task of determining solutions to enable the network owners to add capacity to the network as quickly as possible. There are many factors which contribute to the duration of an upgrade, such as manufacturing back log, configuration of the network, equipment needs, customs clearance, commercial terms and testing intervals. Some of these factors can be addressed prior to when an upgrade is needed, which would allow for quicker implementation. However, these solutions will require an increase in capital during the initial system deployment or during a previous upgrade if one has already been added to the network. Commercial arrangements with a long term validity period would also be helpful in expediting the upgrade. This could minimize negotiations and enable an owner to place an order for capacity without negotiating price and terms. The last factor which can improve the time to upgrade is the owner's comfort with a supplier's technology. If an owner has experience with the current technology the supplier is providing, the owner may allow for reduced testing intervals.

2 COMMERCIAL CONSIDERATIONS

Whether an upgrade is to be plug and play or expedited through reduced testing intervals, pre-established commercial terms will also allow for quicker upgrades. Typically each upgrade contract is negotiated between the supplier and owner of the system. This can easily take months to complete. A potential path forward would be for an owner and supplier to agree to a contract for upgrades, including a clause that allows for the owner to place an order for capacity. The owner can just give formal notice to proceed with the upgrade and the contract would have provisions to allow for the supplier to begin ordering materials for manufacture upon receipt of a down payment. The price and terms are agreed to and the contract allows for a validity period that supports the needs of both parties. The contract can include cost and schedule provisions for specific quantities of point to point wavelengths ordered.

3 MANUFACTURING INTERVALS

The most critical item in the speed of implementation of an upgrade is the manufacturing queue and component lead times. Suppliers continue to manage the component vendor delivery intervals to improve the time needed to receive materials for the manufacture of circuit packs, as well as materials needed for ancillary equipment. Suppliers are not at a just in time delivery interval with component vendors due to financial commitments and due to the need to keep upgrade pricing low. Therefore, there will be some lead time to receive components from the time of order.

An improvement in the yield of components to minimize re-test at the component vendor or supplier's factory, as well as automation in test procedures, allows the manufacturing test interval to be reduced. Manufacturing intervals may be further reduced through elimination of owner witnessed factory acceptance testing. Typically owners have witnessed the testing of the transmission equipment during the base system implementation and are familiar with the equipment and expected test results. For the upgrade, it is recommended that the owners review test results versus witnessing a repeat of the manufacturing tests. Depending on the size of the capacity upgrade, this could save approximately two weeks and does not add risk to the owners.

4 PLUG AND PLAY UPGRADES

The quickest way to install and test an upgrade would be for the owner to place an order for capacity and for the supplier to send the materials to the station upon completion of manufacturing tests. The station management staff would then plug in a transmission circuit pack, connects optical fiber jumpers, and run a software program to configure the wavelength. This solution requires an owner to plan for the future from day one, it also requires that the same technology for which the system was initially designed to be used to upgrade the system. For example, a system designed for 2.5 Gbs technology that is upgraded with 10 Gbs transmission equipment would not be a good candidate for a plug and play upgrade.

Modification to traditional designs to plan for plug and play upgrades requires that additional capital be spent during the initial installation of the system. The modification to the traditional design may require that an alternate, less cost effective, wet plant design be implemented during initial system deployment. The solution for day one would also depend on the length of the system and whether or not a repeatered or repeaterless solution is required. For example in this section, it is assumed that the system is repeatered and the length is greater than 3,000 km. The best wet plant system design for this would be a dispersion managed fiber system which would reduce or eliminate different per channel (wavelength) accumulated dispersion and may not require as much terminal line amplification. This wet plant design would be more costly than a traditional wet plant design for a system of this length. Another portion of the network that needs to be built out on day one is the filtering of the wavelengths and line amplification. The entire wavelength terminal equipment would have to include splitters, couplers and filters for the entire selection of wavelengths.

During initial deployment, the system should be characterized for bandwidth, optical signal to noise ratio (OSNR) and performance. This will confirm that the wet plant was manufactured and installed as per design as well as ensuring the easiness of inserting new wavelengths in the future and re-configuring the network, if needed. Additional testing may also be added to the test program during system commissioning, which confirms that all wavelengths to be installed by the station staff are supported with the installed infrastructure.

Another critical item to make this approach successful is the development of software to configure the wavelength and optimize the performance. The software would require fully developed auto discovery to configure the new wavelength and testing for Q measurements, output power and any other critical measurements. The software would then lead the station staff through a series of techniques for optimization of the performance of the upgrade wavelengths. Training of station personnel would also be required and the first few upgrades may require suppliers to provide test engineers on site to troubleshoot any unexpected problems.

The duration of an upgrade using a plug and play philosophy would then consist of the time it takes to manufacture, test and ship the circuit pack, plus a day or two for configuring the wavelength. In the case of an emergency need for additional capacity, an owner can even decide to use a spare card at each location to provide more capacity while awaiting the delivery of the transmission circuit packs.

Unfortunately, plug and play upgrades are not currently possible and would require significant efforts by suppliers to develop. However, with non fiber-based technology modifications in gratings and electronic compensation, it may become possible in the future for systems which have been designed for a specific technology. This means that older systems upgrading with new technology beyond the original design capacity would be very difficult to implement a plug and play solution. Also, systems where the digital line segment is modified during an upgrade caused by a landing location being bypassed due to reduced capacity needs, will not be able to go to a plug and play upgrade.

The industry has not driven the need for plug and play upgrade capability. However, it has driven the need to upgrade in a shortened interval. This can be accomplished by providing the infrastructure for the next set of upgrade wavelengths during the installation of the base system or during a previous upgrade and reducing the testing needed to configure the network.

5 INSTALLED INFRASTRUCTURE FOR FUTURE UPGRADES AND REDUCED TESTING INTERVALS

Another improvement to current upgrade intervals would be realized if the equipment infrastructure for the next set of upgrade wavelengths is installed during a previous installation and a reduced testing interval was accepted by the owner. As with the pre-established commercial agreement discussed earlier in this paper, a commissioning plan can be agreed to and be part of the contract so that time does not have to be spent on development of the testing plan. For discussion in this section regarding intervals, it is assumed that the engineering of the current system implementation or system upgrade would include planning for an eight wavelength upgrade without adding bays and without requiring a network event to remove traffic from a fiber pair.

The wavelength terminal equipment components and terminal line amplification would be the key components to be in place prior to the new upgrade implementation. This will require that additional bays and shelves be installed for the new wavelengths and dispersion compensating fiber and, in addition, that the wavelength termination couplers and filter paths be defined and installed. Terminal line amplification circuit packs needed for future capacity would also be installed prior to the next upgrade. The installation of this equipment can occur while the current upgrade or base system is being tested. The added cost of adding this equipment earlier than is required for a traditional upgrade is minimal.

The only requirement for installation of the future upgrade would therefore be the insertion of the transmission circuit pack and wavelength filter, connection of the optical fiber into the transmitter, and the adjustment of dispersion compensation. Since all of these items are small, air shipment of equipment can be easily done without incurring significant additional charges. This alone can reduce the upgrade interval by a month. In addition to this, the system owner can also decide to purchase wavelength filters in advance and use system spares in case of emergency.

Historic acceptable performance of a technology should allow owners to accept a reduced set of site acceptance and commissioning tests as well as a reduced testing interval for those tests that are required. The traditional tests performed during an upgrade are shown in Table 1. These tests typically take 38 days to complete. A reduced set of tests shown in Table 2 could be conducted in half the time, 19 days, to ensure performance of key parameters. This will indicate to owners that the new wavelengths will meet the commissioning limits as defined in the commissioning test plan. Confidence trials would be minimized to twenty-four hours and the owner test period can be eliminated. There is minimal risk to the owners because the new equipment has a warranty from the supplier and if there is a problem, the supplier will fix it.

This reduced testing plan has proven to be successful and has been implemented on a system that allowed eight wavelengths to be commissioned within two and a half weeks of receipt of the equipment at the terminal stations. The equipment continues to perform above the commissioning limits and was able to meet the owners' need for a capacity shortfall.

6 CONCLUSION

It is clear that owners need to upgrade systems as quickly as possible to reduce the risk of potentially losing a capacity sale opportunity if they do not have the network capacity to sell. Suppliers continue to work to improve the time to implement upgrades; however, they are a long way from being able to add capacity to the network and have that capacity automatically configured. Component supply chains will have to continue to be worked to minimize lead time. Factory testing intervals will continue to improve as yield improves and testing becomes fully automated to include critical testing.

Since plug and play is presently not available, the quickest way to implement an upgrade is to prepare for it ahead of time by installing the infrastructure and using a reduced testing program. The reduced testing program has been successfully implemented and enabled an owner to add eight point-to-point wavelengths nineteen days after the equipment arrived on site. In addition to a reduction in tests performed during an upgrade, technology improvements in hardware and software have enabled the optimization of wavelengths and a reduction in testing intervals. This has reduced the time to add the upgrade wavelengths to the system.

Table 1: Typical In Station and Commissioning Tests

In Station Testing Description	Time (Days)
SLTE Provisioning	2
EMS In Station Functionality	3
HPOE Line Transmitter Optical Power	1
HPOE Line Receiver Performance	1
HPOE SDH Transmitter Optical Power	1
HPOE SDH Receiver Performance	1
HPOE Transmitter	1
HPOE Alarm Verification and Power Suite Independence	1
HPOE Overnight Stability Standalone BER	0.5
TLA Output Power	1
ILE Output Power	1
LME database loading	1
In Station Confidence Trial	7

Commissioning Testing Description	Time (Days)
Pre-Upgrade Measurements	0.5
New Channel Insertion	0.75
Receive DCF Optimization	2
End to End System Optimization	2
Baseline Measurements	0.5
System Q Performance and Baseline	1
Overhead Channel Transmission	0.5
Wavelength Independence	0.5
AMS Insertion	0.5
Confidence Trial 7 Days	7
LME measurements	1

Table 2:Reduced In Station and Commissioning Tests

In Station Testing Description	Time (Days)
SLTE Provisioning	2
EMS In Station Functionality and HPOE Alarm Verification and Power Suite Independence	3
HPOE Line Transmitter Optical Power	1
HPOE SDH Transmitter Optical Power	1
HPOE Overnight Stability Standalone BER	0.5
TLA Output Power	1
ILE Output Power	1
LME database loading	1

Commissioning Testing Description	Time (Days)
Receive DCF Optimization	2
End to End System Optimization	2
Overhead Channel Transmission	0.5
System Q Performance and Baseline Confidence Trial 3 Days	3
LME measurements	1