NEW BRANCH CONSTRUCTION OF THIRD PARTY EXISTING SUBMARINE CABLE SYSTEM IN EAC1 QINGDAO LANDING EXTENSION

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Abstract: EAC1 Qingdao Landing Extension has been successfully installed, commissioned and entered into commercial service in July 2006 as part of East Asia Crossing Network. This extension provides the additional connectivity to Mainland China for EAC to support the IT and Video traffic growth in the period up to the Beijing Olympic Games in 2008. This paper describes the design approach and implementation of a hybrid submarine system, which comprises an existing cable segment and a newly extended submarine part from multiple suppliers, to enable inter-working without compromise of the original design performance. The system has operated well, and a further capacity upgrade has been implemented in September 2006 which shows the viability and success of the hybrid system design.

1 INTRODUCTION

The system, called EAC1 Qingdao Extension, extends the existing EAC1 submarine cable network toward Qingdao in mainland China. The extension was performed by inserting a Branching Unit (BU) 340 km offshore of Qingdao, dividing two fibre pairs (FP) out of the existing four FP cables between Taiwan and Korea with a length of 2,068 km. The system length via the BU between Qingdao and Taiwan is 2,193km, and that between Qingdao and Korea is 629km. The original EAC1 system employed Dense Wavelength Division Multiplexed (DWDM) technologies with 37.5GHz wavelength spacing, realizing 10Gb/s x 64 WDM x 4FP, and hence ultimate transmission capacity of 2.56Tb/s.

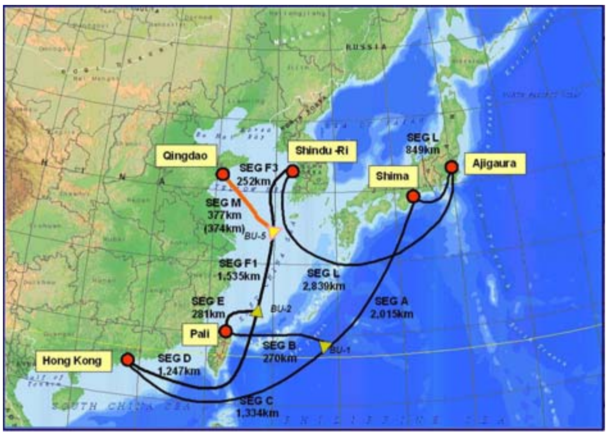

Figure 1 Route Map for EAC1 Qingdao Landing Extension

In order to integrate the NEC proprietary system and the existing system designed by the original supplier, the following design approach was employed.

a) Keeping the original design parameters and actual data of the existing system, especially for channel spacing and optical amplifier characteristics of the submersible repeaters

b) Effectively re-using the original WDM Multiplexer at the existing stations. Service channels with idle tone were employed to keep the optical power constant in the submarine line.

c) Introducing NEC proprietary WME with CW light source to new station, providing compatibility with the WDM Multiplexer at opposite cable landing station.

d) For submarine line monitoring, the originally supplied supervisory equipment remains as it is to monitor the existing line up to the Branching Unit (BU).

e) NEC proprietary Remote Fibre Test Equipment (RFTE) was introduced to monitor the newly installed submarine line up to the BU

f) In order to provide better Operation and Maintenance capability within the total ring system, the power feeding configuration employed single-end power feeding from Qingdao up to the non-switching type BU for powering of the new submarine segment, while maintaining the existing power feeding configuration as it was.

g) The PFE supplied at Qingdao is located at separate station, close to the cable landing point, in order to secure the stability of power feeding.

h) The submarine cable route was selected based on the marine route survey of the original installation, and an additional shore end marine survey was implemented to adjust the cable landing point at Qingdao. The cable protection specification was upgraded to 3m plough burial for better security, considering the heavy fishing activity in the China continental shelf.

i) The optical land cable route was arranged for route diversity to the cable landing station, approximately 15km inland, for better security of traffic.

j) In order to minimize the system outage of the existing segment, and to reduce the risk of node isolation under ring switching whilst the segment commissioning testing of the Qingdao extension was performed, a special loop back scheme was prepared at the beach manhole to retrieve the live traffic immediately in such circumstances.

The following is a detailed description of the above items.

2 SYSTEM DESIGN

2.1 Line Design

The combined system including the newly built extension was required to be designed to keep the originally designed performance without sacrificing any capacity though the system parameters of the segments were different. In 2002 NEC had implemented a transmission experiment between Korea and Taiwan by employing a proprietarily WDM emulator to evaluate the actual performance of the installed submarine segments. Therefore, the experimental data as well as the latest actual data from the maintenance records between Taiwan and Korea, such as cable loss, chromatic dispersion, gain flatness and Q value etc., were available in the design stage for the Qingdao extension to achieve 64WDM transmission performance with a 25 year system design life. In addition, this hybrid system design was examined and confirmed throughout careful computer simulation and laboratory demonstration, in terms of SNR, gain flatness, gain bandwidth, dispersion mapping and signal-level diagrams. The demonstration circuits were configured using a 500km loop with two characteristics of optical amplifiers (one for to represent the new NEC repeaters and the other to represent the existing repeaters) for such characteristics as amplifier gain, bandwidth, noise figure, repeater spacing, etc. By these laboratory experiments, the transmission performance and Q value to support 64 WDM with system life of 25 years at the longest segment of approximately 2400km was confirmed. In addition, the transmission performance at loop back configuration at cable landing point (with total span of 2,900km between Taiwan – Qingdao – Korea) was confirmed in preparation for the case of emergency recovery mentioned previously.

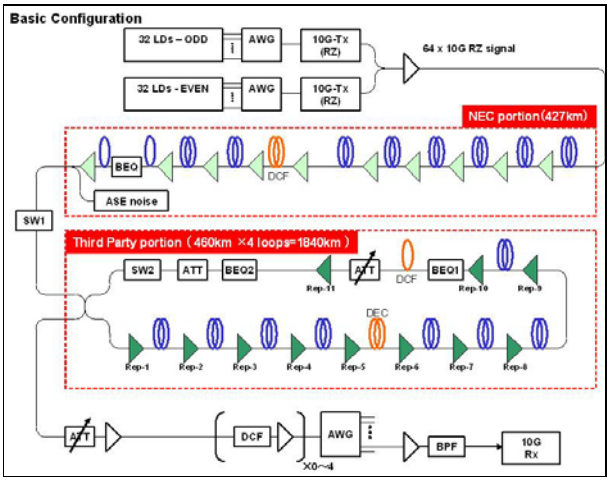

Figure 2 Diagram of Looped Test-bed

2.2 WDM Scheme

After the line performance design, the key technical issue to be established is the wavelength multiplex/demultiplex scheme to combine the existing and newly supplied portion at the cable landing station. For the Qingdao Extension, we adopted a quite unique approach to achieve this, by utilising two different kinds of WDM equipment at the LTE, one for the existing WDM and the other for our proprietary WME. Obviously, NEC proprietary SLTM's, which are 10G transponders, are configured with both kinds WDM equipment to correspond to the line format, including FEC encoding scheme. This provides enormous advantages to the system Purchaser:

a) Operation and Maintenance of the existing system is unchanged

b) Minimisation of outage during Upgrade Installation

c) Pre-emphasis adjustment is not needed to keep the existing setting of idle tone

d)The line monitoring function can be kept as it is.

e) It is an economical Solution

In order to achieve this technical scheme, the NEC proprietary WME had to undergo certain design modifications to achieve a channel spacing of 37.5GHz and CW lighting scheme (dummy lights) corresponding to optical power adjustment scheme employing for the existing WDM equipment. In addition, the power adjustment setting of SLTM and supplemental circuits was engineered to achieve the original level diagram at the existing WDM equipment.

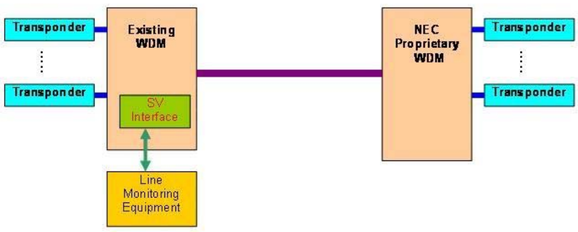

Figure 3 The Monitoring Scheme for the existing and new wet plant

2.3 Wet Plant Supervisory Scheme

Wet plant monitoring is vital in combined systems. In this extension system, seamless wet plant monitoring was realized by introducing dedicated supervisory equipment for the newly installed wet plant, while the existing equipment was maintained by the originally supplied monitoring equipment for the existing wet plant. The new RFTE, which is an enhanced Coherent OTDR in optical query scheme, was utilized for the newly installed wet plant of the Qingdao Extension, to monitor repeater gain and fibre performance. The original supervisory system was a combination of a command response scheme and a normal Coherent OTDR. Although each supervisory system relies on a different architecture, by special engineering, both schemes were confirmed to be able to co-exist each other with negligible interference, realizing a very effective seamless monitoring system.

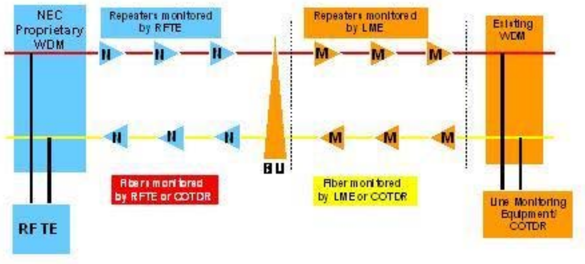

Figure 4 Wet Plant Monitoring Scheme

2.4 Power Feeding Scheme

The power feeding for the Qingdao Extension is shown in Figure 5. There were a number of technical options for the Power Feeding scheme, such as adopting a switchable BU and double-ended power feeding. There was considerable discussion with the system Purchaser considering the survivability of the Qingdao segment traffic and other traffic in the EAC ring, and also the O&M complexity and associated trade-offs. Finally it was concluded that the power feeding configuration should be completely isolated from the trunk segment and should operate in single-ended power feeding mode. This achieves not only simple and sure operability, but also minimum risk of traffic isolation at Qingdao station. Other benefits of this configuration are the clear demarcation in case of any fault between the Qingdao Extension and the existing system, and simplified O&M with increased operator safety. In order to secure the reliability of the power feeding for Qingdao Extension, a redundant type PFE was installed in the Qingdao PFE Station. The Qingdao PFE Station is located in the cable landing point area, not at the Qingdao LTE Station, so that the shortened power feeding cable in the land section can reduce the induced interference from environmental causes.

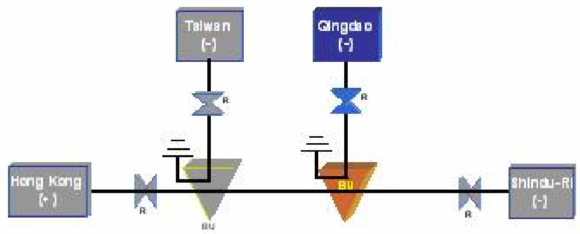

Figure 5 Power Feeding Configuration

2.5 Route Diversity for Land Cable

Two distinct land cable routes were chosen to provide optical land cable route-diversity. These land cable routes were to further enhance the protection of the system against land cable failures. Qingdao is connected to Taiwan and Korea by a four fibre pair cable (2 fibre pairs for each direction). This 4 fibre pair is split into two distinct routes as follows:

a) Route 1 contains 1 optical fibber pair from Taiwan and 1 optical fibre pair from Korea.

b) Route 2 also contains 1 optical fibre pair from Taiwan and 1 optical fibre pair from Korea.

Route 2 also contains the power feed and earth cable from beach manhole to the PFE Station.

2.6 Emergency Loop-Back

Their was a possibility for the marine installation to proceed earlier than the dry plant installation, and in order to minimize the planned outage period after completion of the BU deployment, an emergency loop-back configuration at Qingdao BMH was prepared. Also these engineering arrangements could be used as part of a contingency plan to temporarily recover the traffic in existing EAC ring, if the system should make a ring switch during the commissioning testing of the newly installed segments, or if any cable fault should happen in other segment in the ring, creating node isolation. For the loop back procedure, the fibre paths were connected in loop-back connection at the beach manhole at Qingdao after completion of the BU deployment. PFE installation was completed prior to the BU deployment, in order to test system. So the traffic between Taiwan and Korea could be maintained temporally until commencement of C&A testing.

By this arrangement, outage the period was not only minimized from original plan, but also the marine installation could be allocated in a window of good weather in the autumn. Finally, the outage was significantly improved. Should this countermeasure be not have been applied, an outage period of several months might have occurred. NEC demonstrated this loop back configuration in the test bed, to verify the transmission performance.

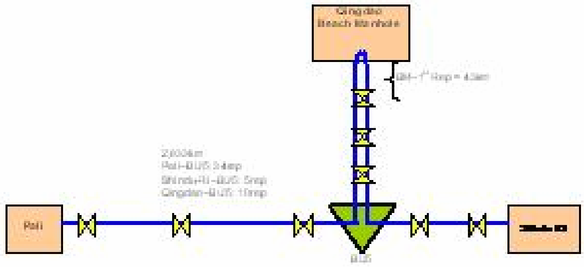

Figure 6 Emergency Loop Back Configuration

3 PROJECT IMPLEMENTATION

The system was handed-over to the system Purchaser within 10 months and 10 days, a relatively short period compared to the other submarine projects of similar size. Timely completion of this submarine system was a mandatory requirement, considering that it is part of the transmission infrastructure which will carry traffic for the 2008 Beijing Olympic Games. A transmission trial for the Olympic Games had been scheduled for August 2006. The system Purchaser and NEC worked in close coordination, and had established an effective project team to expedite the all of the processes of the project implementation.

3.1 Marine Route Survey and Permission

One of key issues of prime concern was the permission for a marine cable route from regional government authorities. The marine route survey for the shore-end modification had been completed within 2 months after project activity commenced. With strong cooperation with the system Purchaser, permission for route itself including the marine route survey and marine installation was secured in a timely manner prior to the planned key activities.

3.2 Land Cable Installation

As well as the marine route survey, the land cable survey was been completed at the same time. The route information including jointing manhole position, the cable piece plan were established and fed back to the cable manufacturing plant. Installation of the land cable was made smoothly and in a timely manner.

3.3 Equipment Manufacturing

Following the consolidation of the system design, including feed back from marine route survey, the equipment manufacturing for the LTE, the submersible repeaters, the BU and the cable was completed within 6 months. The submersible plant was assembled at the cable factory in one length, to confirm its line-performance prior to loading aboard the cable ship.

3.4 Marine Installation

The marine installation period was finally scheduled in mid- winter according to the completion of the submersible plant and associated permissions. In order to increase the endurance against adverse weather, the cable ship was carefully selected for its high manoeuvrability supported by a Dynamic Positioning Capability and for its Plough Deck Handling Machinery. In addition, the requirement for 3m burial capability was one of conditions for selection of the cable ship. CS Fu Hai, which belongs to SBSS in Shanghai, was finally employed, taking consideration for the vessel performance including 3m ploughing track records and its regional experience.

Figure 7 CS Fu Hai

The submersible plant comprising 340km of cable and including 5 repeaters was loaded onto CS Fu Hai at the OCC Kita Kyushu plant, and the CS Fu Hai directly landed the cable-end at the Qingdao landing point in February, 2006.

Figure 8 Cable Landing at Qingdao

Prior to the 3m burial, a detailed study on ploughability along the cable route was carried out, based on NEC's statistical data records for 3m burial installation over a thousand km off China, in order to examine the seabed features were confirmed by the marine route survey. The results of this ploughability assessment and the penetration experienced on the actual cable route corresponded well, so that installation was fully under the control of the vessel commander to adjust the towing speed precisely in order to maximize the plough shear penetration to position the cable a deep as possible.

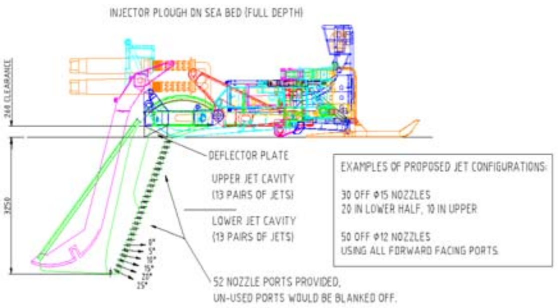

Figure 9 3m Burial "High Plough Injector"

3.5 Commissioning & Acceptance Test

The key features of the commissioning and acceptance test for EAC1 Qingdao Extension were that the segment performance should be confirmed within a minimum period once BU was connected into the existing system, and then to configure the full hybrid segment in conjunction with the newly installed submarine segment and the existing segment. The test procedures were discussed with the system Purchaser and carefully established to achieve these objectives. Immediately after the BU splicing was completed, the system performance between the cable landing station and the BU was confirmed to be according to the system design, and the commissioning and acceptance testing including full confidence trial was completed ahead the schedule.

4 CONCLUSION

This paper discussed the design approach for a hybrid submarine cable system, which combines submarine systems from different suppliers and which are different in their proprietary designs. The design approach achieved the high performance of 64WDM transmission without sacrificing the original design, as well as an economical and O&M oriented solution. The project implementation was smooth, with excellent cooperation between the system Purchaser and supplier, and a relatively short delivery time of 10 months and 10 days was achieved. The system is now in commercial operation, is working in good order and so is fully prepared to support the signal distribution of Beijing Olympic Games in 2008.

5 ACKNOWLEDGEMENT

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6 REFERENCE

"Advanced 3m Burial System and Application into Heavy Fishing Area" by Makoto Saitoh, SubOptic 2004.