Connecting Continents and Communities

Submarine Telecom Cable Solutions
The turnkey partner for the design, build and delivery of your global capacity infrastructure

Optical Submarine Cable systems play a principal role in international telecommunications, thanks to their superiority over satellite systems in terms of stability, latency and upgradability. NEC has been a leading supplier to the submarine cable market since the 1960s.

To guarantee flawless system operation over 25 years in deep water, NEC provides a full turnkey solution including system engineering, production of key elements (submersible repeaters, cables and terminal equipment), system integration, marine installation, commissioning, and long-term maintenance support.

“We have selected NEC as a trusted partner because it is one of the most experienced submarine system suppliers, and can deliver the system on time to meet market demand”

Customer quotation in NEC Press Release
Turnkey Submarine Networks

For those of our customers who prefer it, NEC offers a full turnkey network service. Having agreed the key business goals and network parameters, NEC manages the entire design and delivery of an ultra-reliable and high performance submarine cable network. This allows our customers to focus on other key areas of their business, knowing that their new network will be commissioned and ready for service on time.

**Typical features of NEC turnkey projects**

- Full customer sign-off of network design and performance characteristics
- Full transparency of end-to-end process with regular reviews and success-related milestones
- Strong centralized coordination of all third parties, reducing risk and ensuring shortest time to market
- Applicable to all scales of cable system from domestic to global
- ‘Ground upwards’ design can make use of existing civil assets where available, or start from a blank sheet
- Business model can be tailored to meet specific customer needs
- A range of financing options are available if required (see p.13)
- NEC professional long-term support over the life of the network ensures continuing revenue from submarine cable assets
Project Management

At NEC, we are proud of our reputation for on-time delivery. Each project we undertake involves a dedicated group of highly-qualified project management professionals, who manage the in-house teams and any subcontractors involved, and present a single point of contact to the customer. NEC has the skills and relationships in place to ensure that the committed plan of work is delivered on time and to the exact specifications agreed, while responding flexibly to outside variables such as weather.

Marine Services

NEC provides a full range of marine services to our customers as part of a turnkey submarine cable project. We have a wealth of experience in deploying cables in all types of marine environment, and across widely-varying geographies and cultures.

Typical Range of Marine Services (see following pages for details)

- Desktop Studies
- Route Survey and Cable Engineering
- Acquisition of Permits
- Route Clearance and Pre-Lay Grapnel Run (PLGR)
- Cable Lay and Plough Burial
- Shore End Landings
- Post Lay Inspection and Burial (PLIB)
- Onboard Testing
- Charting & Documentation

The NEC Philosophy

NEC’s approach to marine services is to select the very best sub-contractors from a long list of approved and qualified partners, and to liaise closely with these to form a coherent unit. In this way, our customers benefit from the choice of the most suitable vessels, equipment and expertise available at the time of the project. This is an approach which optimises the cost of the marine installation, as NEC will never be paying for a vessel or crew which is idle. Furthermore, we have the ability to obtain the most commercially competitive operations, while still controlling quality, compliance and safety.

Some Subcontractor Selection Criteria

- Experience and Skills in Required Operations
- Track Record in Region
- Quality Assurance Processes
- Safety Record
- Specification and Availability of Vessel(s)
- Specification of Onboard Equipment
- Technical Compliance
- Commercial Compliance
- Plan of Work and Schedule Flexibility
- Competitiveness of Offer
Desktop Survey (DTS)
Having confirmed with the Purchaser the locations of the cable landing stations and beach manholes (if they already exist), we will propose an initial Straight Line Diagram (SLD) and Route Position List (RPL) for the cable. This is based on multiple factors such as the known condition of the sea bed along the route, fishing and other shipping activity in the area, and the existence of cables, pipelines and other features such as sea mounts, wrecks, etc. The DTS also results in the creation of a Survey Operation Plan, which will be used to define the scope of the survey contractor and to manage its operations.

Acquisition of Permits
NEC can manage the process of obtaining all necessary permits, including: access rights; cable landing licenses; cable and pipeline crossing agreements; seabed occupancy permits and associated environmental surveys, studies and reports. In addition to in-house expertise, we have a well-established global network of specialists who mitigate the permitting processes at local, regional and national levels to de-risk the project and avert delays in approvals.

Route Clearance and Pre-Lay Grapnel Run
Route Clearance operations remove known obstacles, such as out-of-service cables, which are recovered. In areas where ploughing is required to bury the new cable, a Pre-Lay Grapnel Run is typically carried out to recover any debris such as fishing gear which might damage the plough.

Marine Route Survey and Cable Engineering
A Marine Route Survey is carried out in order to obtain detailed information on the bathymetry, seabed condition, and other features along the proposed cable route. The Survey Operation Plan will define the geophysical and geotechnical survey processes to be performed, allowing NEC to mobilize the most appropriate vessel and on-board equipment for the task. A range of field operations may be called for to refine the cable route and determine the most effective cable protection method(s), such as:
- Bathymetric Sounding
- Side Scan Sonar Sweep
- Sub-Bottom Profiling
- Landing Point Measurements
- Sea Bottom Sampling
- Burial Assessment Tests

Post-fieldwork analysis of the acquired data, along with detailed local knowledge of all hazards and restrictions, allows an optimized route to be selected. A detailed Route Position List (RPL) and a Straight Line Diagram (SLD) are produced, with cable type and slack allocations. From the final Marine Route Survey Report, Marine Installation Procedures are constructed to define the subsequent phases of the installation.
Main Lay and Cable Burial
In order to install the cable network, one or more suitable cable ships will be mobilized. These cable installation vessels will be equipped to bury the cable to the pre-determined depth and to perform cable jointing operations on board. Precise route tracking and slack control ensure that the cable is laid according to the RPL. State-of-the-art navigation systems such as Differential GPS and an accurate cable laying monitoring system are used to achieve precise cable installation. Protection of the cable is achieved by burying the cable to a target depth determined by the condition of the seabed, where possible by simultaneous lay and bury operation.

Shore End Landings
Analysis of the results of the Marine Route Survey will identify which Shore End landings can be directly installed from the main cable vessel, and which must be installed by a small vessel or specially rigged barge to access shallow water. Under the command of qualified personnel, the cable is landed. The landed cable may be buried and/or external material attached to enhance its protection.

Post-Lay Inspection and Burial (PLIB)
Operational circumstances may result in sections of cable being unburied on the seabed. In order to bury these cables to the specified target burial depth, Post Lay Inspection and Burial by means of water jetting by Remotely Operated Vehicles (ROVs) is carried out. Key areas for PLIB operations include the Shore End to Main Cable Interface and cable and pipeline crossings.

On-Board Testing
NEC dispatches its own qualified engineers onboard during the entire cable installation period to monitor the integrity of the installed submersible plant, using onboard power feeding and transmission testing equipment.

Charting and Documentation
After completion of the installation, the Purchasers are provided with comprehensive charts and data to support subsequent Operations and Maintenance.
Solutions for Submarine Repeated and Repeaterless Systems

Key benefits

- DWDM technology and advanced modulation enable 24Tbps total capacity per fiber pair
- 192Tbps capacity can be achieved over a cable of 8 fiber pairs
- Transmission distances in excess of 12,000km for trans-oceanic networks
- Extremely reliable submarine network over 25 years’ life
- Highly agile and flexible solution for growing capacity demands

Example solution (repeated applications)

**Location A**
- LTE
- CTB
- PFE

**Location B**
- LTE
- CTB
- SW
- PFE

**Location C**
- LTE
- CTB
- PFE

Branching Unit
- Equalizer
- Repeater

LTE: Line Terminal Equipment
PFE: Power Feeding Equipment
CTB: Cable Termination Box
SW: Switch

Example solution (repeaterless applications)

**Location A**
- LTE
- PFE
- IRPA
- SW

**Location B**
- LTE
- SW

Tx signal - IRPA
- Pumping signal @ 1480nm

LTE: Line Terminal Equipment
SW: Switch
IRPA: In-line Remote Pre-Amplifier (depending on system length)
Line Terminal Equipment

To transport high-capacity DWDM signals over transoceanic distances, specialized Line Terminal Equipment is required. This equipment delimits the undersea portion of the network, using high speed advanced signal processing techniques to allow the recovery of the original signals after their journey through the submarine cable.

Key features

- Highly Dense Wavelength Multiplexing and Demultiplexing
- Transmission capacity of up to 24Tbps per fiber pair in the C-band
- Over 192Tbps (24Tbps x 8 fiber pairs) of cross-sectional capacity
- Software-configurable choice of modulation format (BPSK, QPSK, 8QAM, 16QAM) to suit any application, to optimize terminal cost per bit, and to allow common spares across the network
- Flexible channel spacing to maximise capacity
- Various and flexible tributary interfaces:
  - 400Gbe
  - 100Gbe, OTU4 (software switchable)
  - STM-64, OC-192, OTU2/2e, 10Gbe LAN-PHY/WAN-PHY (software switchable)
- Advanced soft decision forward error correction function
- Digital Coherent transponders provide automatic dispersion compensation and polarization demultiplexing
- Simplified maintenance by plug and play scheme
- Minimal footprint and power consumption
- In-service upgrade without traffic interruption
- Applicable to both repeater-based and repeaterless cable systems
Submarine Repeaters

The NEC R640SW Submarine Repeater has been specially designed for DWDM applications and uses Erbium Doped Fiber Amplifiers (EDFAs) pumped at 980nm by laser diodes in a highly redundant configuration. This technology enables high power amplification for optimized repeater spacing, wide and flat amplification gain to allow for efficient channel spacing, and a lower noise figure which results in more capacity over longer distances with the highest reliability. Each standard repeater is designed to accommodate up to eight amplifier systems (fiber pairs).

Key features

- Specially designed for highly reliable DWDM applications
- Employs 980nm pumped Erbium Doped Fiber Amplifiers
- Highly redundant pumping, with 4 pump laser diodes per amplifier pair
- Extremely reliable power circuits
- Wide and flat amplifier gain
- Low noise figure
- Accommodates up to 8 amplifier systems (fiber pairs)
- Ultra pressure-resistant housing for water depths up to 8,000m
- Compact size to facilitate deployment and shipboard handling
Branching Units

Branching Units (BUs) provide fiber transmission paths and power feeding paths to branch landing stations. The use of BUs allows for more economical network design and excellent networking flexibility in serving multiple landings. Four types are available: Fiber Branch BUs, Fixed OADM BUs, Reconfigurable OADM (ROADM) BUs, and WSS-based Switchable OADM (SOADM) BUs. All feature remote power path switching capability.

### Key features
- Reliable design for up to 8,000m water depth
- Wide choice of OADM options
- BU powering can be controlled through multiple fiber paths, even with major faults such as cable cuts
- 4-port BU available for use in special applications

### Main benefits
- ROADM and SOADM BU options allow in-service changes to branch capacity according to traffic demand
- Highly flexible Add-Drop capacity, configurable down to the scale of individual wavelength channels
- End-to-end OADM fiber path monitoring via the network management system simplifies operations

Remote Fiber Test Equipment (RFTE)

This equipment is used to identify and isolate any faults in the wet plant, providing full visibility of repeaters and span cable.

### Key features
- Monitors up to 8 fiber pairs with one RFTE
- Simultaneous in-service monitoring from all stations
- Determines the faulty repeater / cable location
- Estimation of faults from cable loss and repeater gain
- Records the history of repeater output over a long period of time
Power Feeding Equipment (PFE)

PFEs located at the cable stations provide a constant electrical current to the wet plant, and power the submersible repeaters. High, Medium and Low voltage PFEs are available depending on the voltage requirements of each link.

Key features

- Supplies precisely controlled constant current (0.5 ~ 1.6 Amp) to submarine repeaters
- Supports broad range of power feeding voltages (up to 15kV)
- Single-end & double-end feeding capability
- High Reliability Design
  - Converter protected in N:1 ratio
  - Current/Voltage sensor protected in 2:1 ratio
  - Equipment duplication for branch stations
  - Automatic protection switching
- Minimum Footprint Design

Management System

WebNSV manages the LTE, RFTE, PFE and their associated networks, using web-based technology. It comprises an Element Management System for individual station management and a Unified Management System for centralized system management.
Submarine Cables

Established in 1935 and now part of the NEC family, OCC has an unsurpassed reputation for the design and manufacture of superior subsea fiber optic cables. The OCC-SC500 series shown here is qualified to 15kV and has been commercially deployed in water depths in excess of 9,000m.
Finance Solutions for Submarine Cable Projects

NEC, together with NEC Capital Solutions Limited (founded in 1978) can provide finance solutions for sales of NEC submarine cable products, through leasing arrangements and a range of other financial schemes. As a major multinational company, NEC also has excellent relationships with Japanese and International banks and other financial institutions, to whom we can introduce our clients at an early stage in the project lifecycle.

Whether your goal is to get assistance for your new submarine cable business through its incubation phase, to finance a major capacity upgrade, or to achieve a different blend of CapEx and OpEx, we would be pleased to support you.

Examples of financial solutions

- Brokering and coordination of bank loans
- Structured finance through Special Purpose Vehicles (SPVs)
- Fixed or variable term lease arrangements
- Pay-as-you-grow models for SLTe procurement
- Export credit and overseas development agency assistance

Typical structured finance scheme - for new cables

Capacity lease between Your Company and the SPV. Once the SPV pays off the loan, title transfers at nominal book value. Your Company’s CapEx is converted to OpEx.
## NEC’s Recent Supply Record (as of April 2016)

### Selected Newly Built Systems since 2001

<table>
<thead>
<tr>
<th>Project</th>
<th>System Length</th>
<th>Total/Partial</th>
<th>In Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>APCN2</td>
<td>19,000 km</td>
<td>Total</td>
<td>2001</td>
</tr>
<tr>
<td>AJC</td>
<td>12,000 km</td>
<td>Total</td>
<td>2001</td>
</tr>
<tr>
<td>EAC2</td>
<td>7,800 km</td>
<td>Total</td>
<td>2002</td>
</tr>
<tr>
<td>Algiers—Palma Cable</td>
<td>310 km</td>
<td>Partial</td>
<td>2002</td>
</tr>
<tr>
<td>HMC</td>
<td>280 km</td>
<td>Total</td>
<td>2002</td>
</tr>
<tr>
<td>TIS</td>
<td>1,100 km</td>
<td>Total</td>
<td>2003</td>
</tr>
<tr>
<td>AUFS-West</td>
<td>2,500 km</td>
<td>Total</td>
<td>2004</td>
</tr>
<tr>
<td>DMCS</td>
<td>150 km</td>
<td>Total</td>
<td>2004</td>
</tr>
<tr>
<td>JASUKA</td>
<td>1,800 km</td>
<td>Total</td>
<td>2006</td>
</tr>
<tr>
<td>BLCS</td>
<td>320 km</td>
<td>Total</td>
<td>2006</td>
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<tr>
<td>EAC1 Qingdao Extension</td>
<td>350 km</td>
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<td>2006</td>
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<tr>
<td>DSCN</td>
<td>1,100 km</td>
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<td>2007</td>
</tr>
<tr>
<td>Russia—Japan Cable Network</td>
<td>1,800 km</td>
<td>Total</td>
<td>2008</td>
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<tr>
<td>Trans-Pacific Express</td>
<td>17,200 km</td>
<td>Partial</td>
<td>2008</td>
</tr>
<tr>
<td>Hokkaido Sakhalin Cable System</td>
<td>560 km</td>
<td>Total</td>
<td>2008</td>
</tr>
<tr>
<td>Balam Singapore Cable System (BSCS)</td>
<td>98 km</td>
<td>Total</td>
<td>2009</td>
</tr>
<tr>
<td>Jakabare</td>
<td>1,400 km</td>
<td>Total</td>
<td>2009</td>
</tr>
<tr>
<td>Asia America Gateway</td>
<td>20,000 km</td>
<td>Partial</td>
<td>2009</td>
</tr>
<tr>
<td>Unity</td>
<td>9,500 km</td>
<td>Partial</td>
<td>2010</td>
</tr>
<tr>
<td>I-ME-WE</td>
<td>12,000 km</td>
<td>Partial</td>
<td>2011</td>
</tr>
<tr>
<td>Japan Domestic (Ogasawara-Tokyo)</td>
<td>1,000 km</td>
<td>Total</td>
<td>2011</td>
</tr>
<tr>
<td>Dhiraagu Domestic Submarine Cable (DDSCN)</td>
<td>1,000 km</td>
<td>Total</td>
<td>2012</td>
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<tr>
<td>Asia Submarine-cable Express (ASE)</td>
<td>7,200 km</td>
<td>Partial</td>
<td>2013</td>
</tr>
<tr>
<td>South-East Asia Japan Cable (SEJC)</td>
<td>8,800 km</td>
<td>Partial</td>
<td>2013</td>
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<td>Asia Pacific Gateway (APG3)</td>
<td>10,400 km</td>
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<td>Ongoing</td>
</tr>
<tr>
<td>Sulawesi Maluku Papua Cable System (SMPCS) Packet 2</td>
<td>3,500 km</td>
<td>Total</td>
<td>Ongoing</td>
</tr>
<tr>
<td>SEA-ME-WE 5 Cable System (SMWS)</td>
<td>20,000 km</td>
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<td>FASTER</td>
<td>9,000 km</td>
<td>Total</td>
<td>Ongoing</td>
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<td>South-East Asia United States Cable System (SEA-US)</td>
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<td>Total</td>
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<tr>
<td>Asia Africa Europe 1 (AAE-1) Hong Kong Extension</td>
<td>2,800 km</td>
<td>Total</td>
<td>Ongoing</td>
</tr>
<tr>
<td>South Atlantic Cable System (SACS)</td>
<td>6,200 km</td>
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<td>Ongoing</td>
</tr>
<tr>
<td>System Kabel Rakyat 1 Malaysia (SKR1M)</td>
<td>3,700 km</td>
<td>Total</td>
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<tr>
<td>ATISAl</td>
<td>279 km</td>
<td>Total</td>
<td>Ongoing</td>
</tr>
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### Selected Capacity Upgrades since 2010

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<tr>
<th>Project</th>
<th>In Service</th>
<th>Project</th>
<th>In Service</th>
<th>Project</th>
<th>In Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>PanAm Upgrade #1</td>
<td>2010</td>
<td>AJC Upgrade</td>
<td>2010</td>
<td>APCN2 Stage 1e/2b Upgrade</td>
<td>2011</td>
</tr>
<tr>
<td>EAC PACIFIC Upgrade</td>
<td>2011</td>
<td>APCN2 Stage 2c Upgrade</td>
<td>2011</td>
<td>JIH Upgrade</td>
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<td>MOG Upgrade</td>
<td>2012</td>
<td>APCN2 Stage 1g/2d Upgrade</td>
<td>2012</td>
<td>AUFS Upgrade</td>
<td>2012</td>
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<tr>
<td>RJCN Upgrade</td>
<td>2012</td>
<td>AUFS Upgrade</td>
<td>2013</td>
<td>JIH Upgrade</td>
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<td>APCN2 Stage 2e Upgrade</td>
<td>2013</td>
<td>HMC Upgrade</td>
<td>2013</td>
<td>DMCS Upgrade</td>
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<td>EAC PACIFIC Upgrade 2013</td>
<td>2013</td>
<td>JSSC Upgrade</td>
<td>2013</td>
<td>APCN2 Stage 2f Upgrade</td>
<td>2014</td>
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<td>JSC Upgrade #1</td>
<td>2014</td>
<td>JASUKA Upgrade</td>
<td>2014</td>
<td>APCN2 Stage 2g Upgrade</td>
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<tr>
<td>AUFS-East/West Upgrade</td>
<td>2014</td>
<td>SUB Upgrade</td>
<td>2015</td>
<td>PanAm Upgrade #2</td>
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<td>AUFS-East/West Upgrade</td>
<td>2014</td>
<td>APCN2 Stage 2h Upgrade</td>
<td>2015</td>
<td>SUB Upgrade</td>
<td>2016</td>
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NEC’s Submarine Network Facilities in Japan

- **OCC Kitakyushu Submarine Cable**
- **Miyagi Plant SLTE, PFE**
- **Yamanashi Plant Repeaters and Branching Units**
- **NEC Headquarters Sales, Marketing, R&D**
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