INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.971

(06/2004)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Optical fibre submarine cable systems

General features of optical fibre submarine cable systems

CAUTION !

PREPUBLISHED RECOMMENDATION

This prepublication is an unedited version of a recently approved Recommendation. It will be replaced by the published version after editing. Therefore, there will be differences between this prepublication and the published version.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU [had/had not] received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

ITU-T Recommendation G.971

General features of optical fibre submarine cable systems

(revised in 2004)

Summary

This Recommendation applies to optical fibre submarine cable systems. The purpose of this Recommendation is to identify the main features of optical fibre submarine cable systems, and to provide generic information on relevant Recommendations in the field of optical fibre submarine cable systems. A common implementation relevant to all the optical fibre submarine cable systems is described in Annex A. Specific information relevant to each optical fibre submarine cable systems is included in Annexes of other Recommendations. The updated data on cable ships and submersible equipment of various countries are also described in the Appendix I.

~~This Recommendation was firstly issued in 1993 and revised in 1996. Amendments have been made taking into account the establishment of new Recommendation (G.977 [6]). An updated version of a list of cable ships and submerged equipments, which was available in the *Blue Book*, Volume III, Supplement 11, is also included.~~

Source and history

1993 ITU-T Recommendation G.971 was created by ITU-T Study Group 15 (1993-1996).

1996 ITU-T Recommendation G.971 was revised by ITU-T Study Group 15 (1993-1996).

2000 ITU-T Recommendation G.971 was revised by ITU-T Study Group 15 (1997-2000) and approved under the WTSC Resolution 1 procedure on 4 April 2000.

200y ITU-T Recommendation G.971 was revised by ITU-T Study Group 15 (2001-2004) and was approved as the 4th version, under the AAP procedure on the XX of MM 200Y. This revision updated Appendix 1, data on cable ships and submarine equipment of various countries. Moreover, any specific information commonly used in relevant Recommendations were included in Annex A.

As seen above, this Recommendation has evolved considerably over the years; therefore the reader is warned to consider the appropriate version to determine the characteristics of already deployed product, taking into account the year of production. In fact, products are expected to comply with the Recommendation that was in force at the time of their manufacture, but may not fully comply with subsequent versions of the Recommendation.

ITU-T Recommendation G.971

General features of optical fibre submarine cable systems

1 Scope

This Recommendation applies to optical fibre submarine cable systems.

The purpose of this Recommendation is to identify the main features of optical fibre submarine cable systems, and to provide generic information on relevant Recommendations in the field of optical fibre submarine cable systems. The Annex A contains common implementation aspects of all optical submarine cable systems.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; ~~all~~ users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation dose not give it, as a stand-alone document, the status of a Recommendation.

2.1 Normative references

The following ITU-T Recommendation contains provisions which, through reference in this text, constitute provisions of this Recommendation.

- ~~[1]~~ ITU-T Recommendation G.972 (~~1997~~2000), *Definition of terms relevant to optical fibre submarine cable systems*.
- ~~[2]~~ ITU-T Recommendation G.973 (~~1996~~2003), *Characteristics of repeaterless optical fibre submarine cable systems*.
- ~~[3]~~ ITU-T Recommendation G.974 (1993), *Characteristics of regenerative optical fibre submarine cable systems.*
- ~~[4]~~ ITU-T Recommendation G.975 (~~1996~~2000), *Forward error correction for submarine systems*.
- ~~[5]~~ ITU-T Recommendation G.975.1 (2004), *Forward error correction for high bit rate DWDM submarine systems.*
- ~~[6]~~ ITU-T Recommendation G.976 (~~1997~~2000), *Test methods applicable to optical fibre submarine cable systems.*
- ~~[7]~~ ITU-T Recommendation G.977 (~~2000~~2004), *Characteristics of optically amplified optical fibre submarine cable systems.*

3 Terms and definitions

Terms used in this Recommendation are defined in ITU-T Recommendation G.972 ~~[1]~~.

4 Abbreviations

This Recommendation uses the following abbreviations.

BU Branching Unit

CTE Cable Terminating Equipment

PFE Power Feeding Equipment

TTE Terminal Transmission Equipment

5 Features of optical fibre submarine cable systems

An optical fibre submarine cable system has specific technical features:

a) A submarine cable system should achieve a long lifetime and a high reliability; the main reason is that, due to the difficulty in accessing the submerged plant, the construction and maintenance of a link are long and expensive; moreover most of submarine links are of strategic importance in the transmission network and the interruption of a link usually results in significant loss of traffic and revenue.

b) A submarine cable system should possess mechanical characteristics which enable it:

1) to be installed accurately with correct slack and with due safety consideration on the sea bed; deep water installations may reach 8000 metres. (In general, submarine cable systems shall be installed, buried or inspected by specially designed cable ships and submerged equipments. Detailed information of such cable ships and submerged equipments (i.e. ploughs, ROVs, etc.) is contained in Appendix I.);

2) to resist the sea bottom environment condition at the installation depth, and particularly hydrostatic pressure, temperature, abrasion, corrosion, and marine life;

3) to be adequately protected (i.e. by armoring or burying) against aggression, due for example to trawlers or anchors;

4) to survive recovery from such a depth, and subsequent repair and relay, with due safety consideration.

c) The material characteristics of a submarine cable system should enable the optical fibre:

1) to achieve its desired reliability over its design lifetime;

2) to tolerate stated loss and aging mechanisms, especially bending, strain, hydrogen, stress, corrosion and radiation.

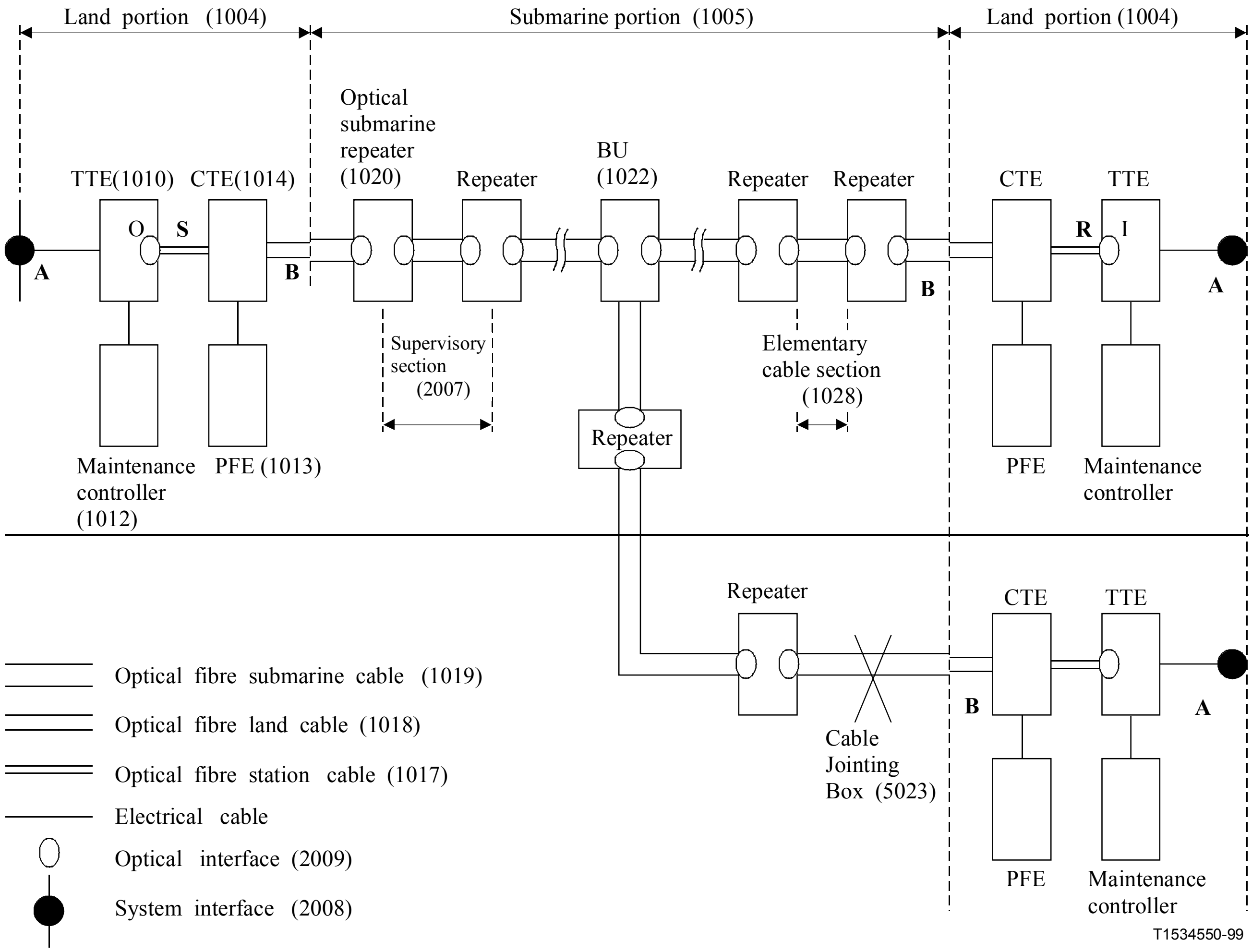
d) The transmission quality of a submarine cable system should follow as a minimum ITU-T Recommendation G.821.

Figure 1 shows the basic concept of optical fibre submarine cable systems and boundaries. Optical submarine repeaters or optical submarine branching units could be included, depending on each system requirement.

In Figure 1, A denotes the system interfaces at the terminal station (where the system can be interfaced to terrestrial digital links or to other submarine cable systems), and B denotes beach joints or landing points. Numbers in brackets in the Figure refer to ITU-T Recommendation G.972 ~~[1]~~.

6 Relationship among Recommendations relevant to optical submarine cable systems

Relationship among the various Recommendations pertaining to optical fibre submarine cable systems are shown in the flow chart presented in Figure 2.



Note 1 – **A** denotes system interface
Note 2 – **B** denotes landing points or beach joints (1006)
Note 3 – X denotes cable jointing box (5023)
Note 4 – Numbers in brackets relate to ITU-T G.972

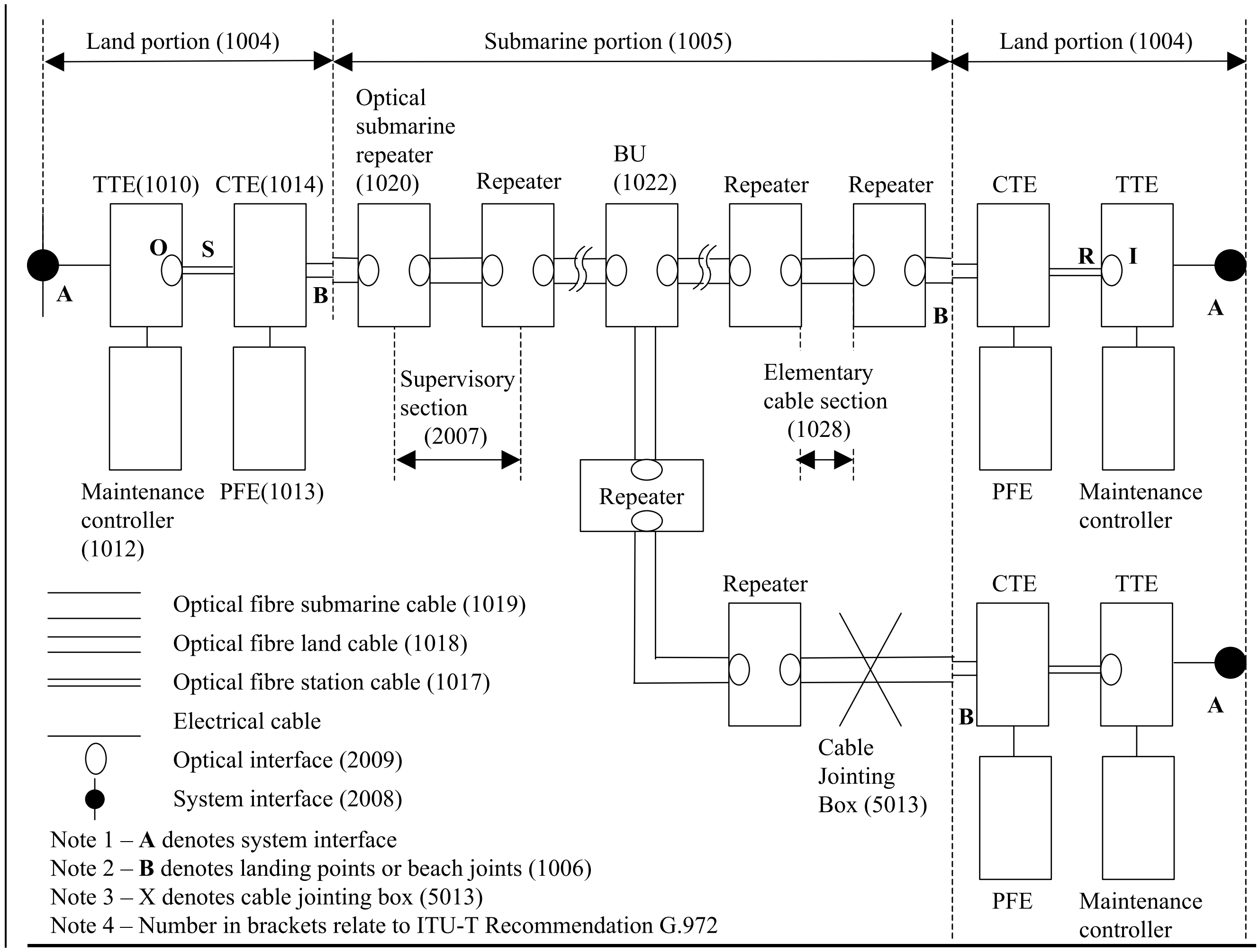
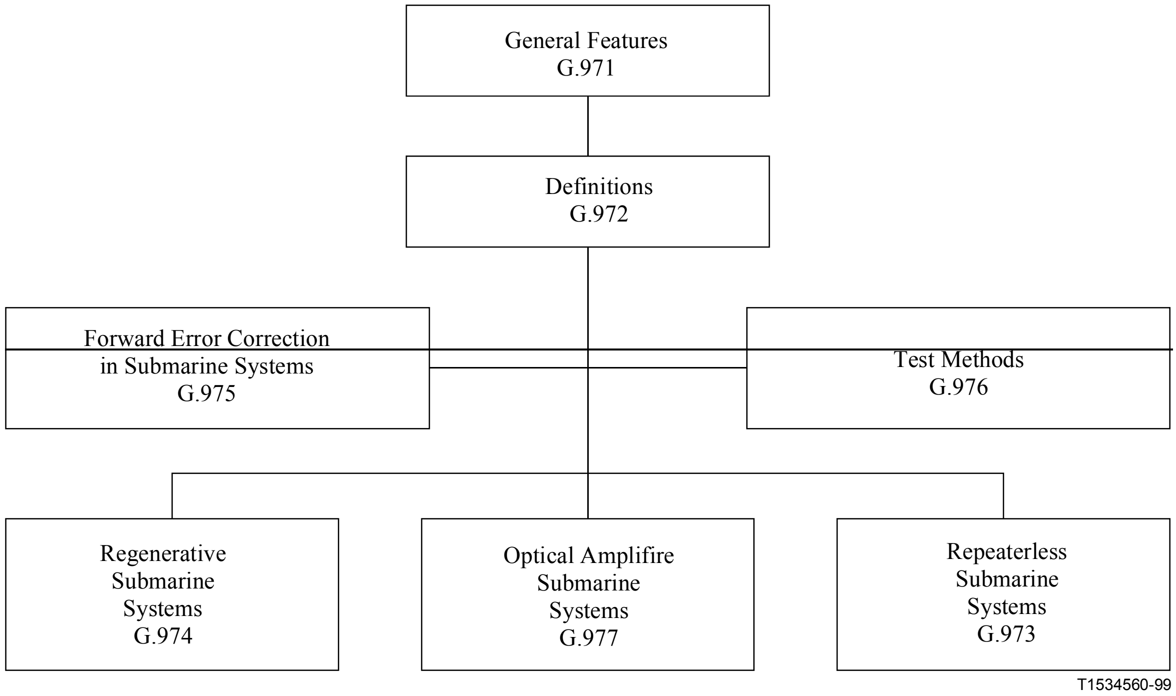


Figure 1/G.971 – Example of optical fibre submarine cable systems



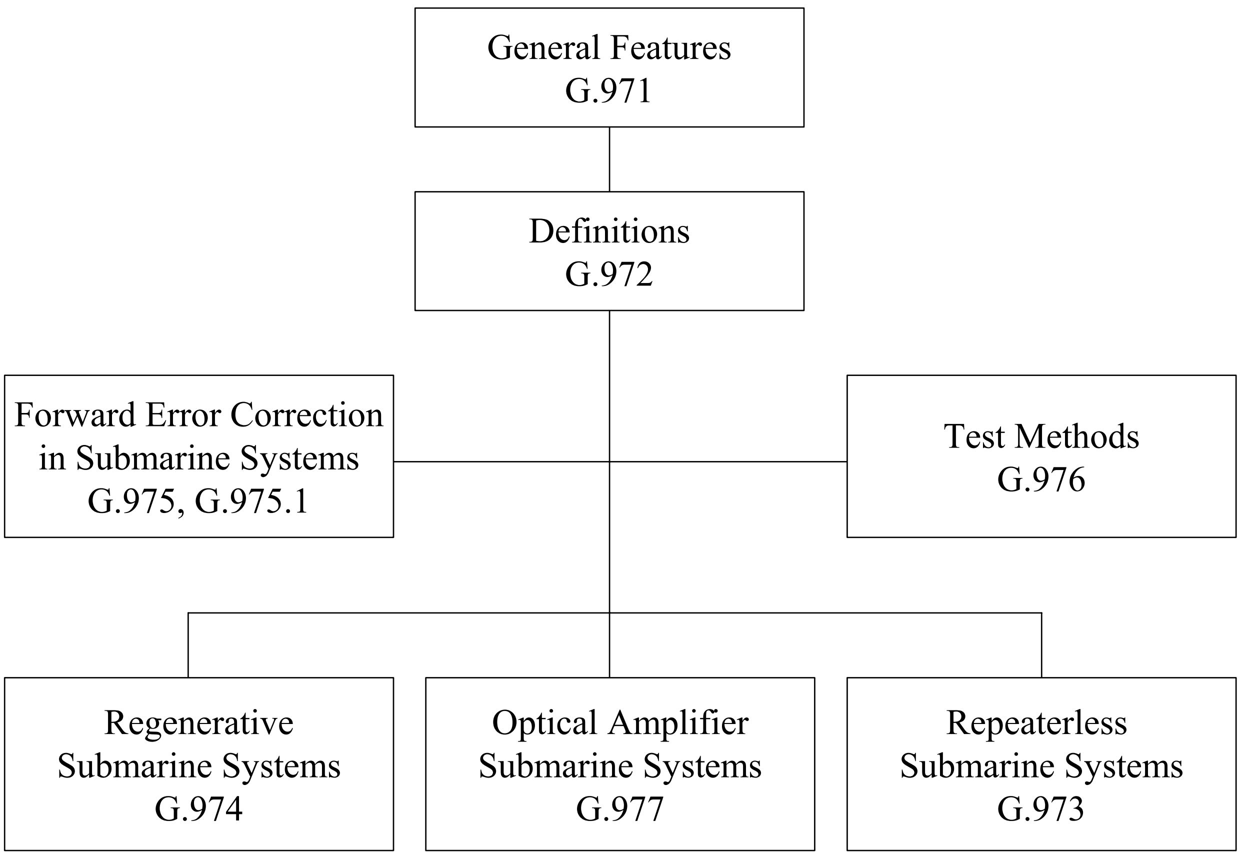


Figure 2/G.971 – Relationship between Recommendations relevant to optical submarine cable systems

ANNEX A

Common implementation aspects of optical submarine cable systems for manufacturing, installing and maintenance

A.1 Introduction

This annex outlines the common aspects of submarine cable systems, which are specified in ITU-T Recommendations G. 973, G.974 and G. 977, such as manufacturing, installation, and maintenance.

The information provided in this ANNEX is intended as a guide to current practice and is not intended as a Recommendation relating to existing or future systems.

A.2 Manufacturing

A.2.1 Quality in optical fibre submarine cable systems

The high performance and reliability requirement established for an optical fibre submarine cable system can be fulfilled only if stringent quality procedures are applied during designing, manufacturing, and laying a system. Although quality procedures are particular to each optical fibre submarine cable supplier, the following basic principles generally apply.

A.2.1.1 Qualification of the designs and technologies

This activity, part of the development process, is intended to demonstrate that the performance of a technology, a component or an assembly is compatible with meeting the overall system performance and gives reasonable confidence that the reliability target can be met. Qualification includes high stress testing, intended to estimate the ruggedness of the technology, component or sub-assembly and to determine the screening procedure, and long term life testing (some of which might be accelerated for instance by the temperature), the purpose of which is to confirm the validity of the screening procedure and to evaluate the life time and/or the reliability of the technology, component or assembly. Qualification of a cable or submarine equipment may also includes sea trials.

A.2.1.2 Certification of components and sub-assemblies

This activity, part of the manufacturing process, is intended to assure the ability of each component or assembly to comply with its performance and reliability specifications once installed. For submarine equipment, each component is individually certified.

The certification is based on the results of screening tests, intended to remove any unsatisfactory item or component, and particularly those likely to exhibit early failures.

A.2.1.3 Manufacturing inspection

This activity, during the manufacturing process, is intended to verify that the Quality Plan is respected, that each operation is accomplished along the agreed procedure, and that the result is satisfactory.

The responsibility for manufacturing inspection can be shared between the manufacturer and the purchasers of an optical fibre submarine cable system.

A.2.1.4 Factory Acceptance Tests

After completion of the manufacturing of each item (TSE and Submerged Equipment), functional and performance tests must be carried out in order to release the equipment from the Factory.

This activity, conducted in Factory, should comprise all tests necessary to confirm that TSE (including final software) and Submerged Equipment (Repeater and Cable sections) are ready for installation or assembly. The tests should demonstrate that the requirements of the Technical Specification will be met by the Segments and the full Network once installed or assembled if no discrepancy occurs during installation or assembly period.

On completion of factory testing, Equipment may be tested during a confidence trial period to control its stability.

A.2.2 Assembly and loading procedure

Link assembly consists of jointing the cable sections, the repeaters and the branching units, together with monitoring that the guaranteed margin is present for each fibre in each cable section, so as to constitute the submarine portion. Link assembly is usually performed in the cable factory prior to loading.

Ship loading consists of installing the submarine portion, or fractions of it, on board the cable ship, prior to laying. Ship loading is generally performed with the link unpowered. Tests are made periodically during loading to confirm that the performance of the assembled equipment has not been affected by the loading process.

A.3 System installation

A.3.1 Submarine route survey

Route survey is performed prior to cable laying so as to select the cable route and means of cable protection (lightweight protection, armour, burial). The route survey consists in studying the sea depth profile, the sea bottom temperature and seasonal variations, the morphology and nature of the sea bottom, the position of existing cables and pipes, the cable fault history, fishing and mining activities, sea current, seismic activity, laws, etc.

A cable route study should normally be carried out prior to the start of a route survey to determine all environmental, political, economic and practical aspects related to the route. Discussions should be held with local authorities and fishing bodies for this purpose, together with inspection of landing sites and access points as necessary.

An assessment of burial feasibility can also be carried out as part of the route survey, either through direct continuous measurement (Burial Assessment Survey, BAS) or discrete periodic measurement (Cone Penetrometer Testing, CPT).

A.3.2 Submarine cable installation

Cable laying is normally performed using a recognized cable-ship after any necessary route clearance in shallow water has been carried out (e.g. pre-lay grapnel run, PLGR).

Laying is normally undertaken only when weather and sea conditions do not create severe risk of damage to the submarine portion, cable ship and laying equipment, or of injury to the personnel.

The cable may be buried in the seabed to increase cable protection. Burial can be undertaken during laying using a sea plow towed by the laying cable ship, or after laying using a self-propelled submersible robot or other means.

During laying, a predetermined cable overlength (slack) is laid, so as to ensure that the cable is properly laid on the sea bottom.

The system should be tested during the laying and at the end of laying, so as to ensure that no significant system degradation has been induced. Laying testing includes transmission and functional tests, and may include tests on redundant subassemblies. To permit test during cable laying, the link may be powered, provided that safety regulations are respected.

A.3.3 Land cable installation and testing

Land Cable tests will be performed after the completion of Land Cable installation at each site to confirm performances.

Especially, the Return Earth System shall be tested after its installation.

A.3.4 Terminal station equipment installation and testing

After completion of Terminal Station Equipment installation activities in the Cable Terminal Station, a Site Acceptance Testing program should be conducted based on the Factory Acceptance Test program already performed. Results of both periods should be compared. In the event of an unfavourable comparison between the two sets of results the cause of the irregularities should be determined.

All equipment units provided as spares shall be tested for correct operation by substitution with working units.

On completion of the suite tests, the equipment shall be subject to a continuous confidence trial period to be defined depending of the equipment type.

Following the Site Acceptance Testing period for each item, interconnection of Equipment should be carried out to control their interoperability. A specific integration test plan should then be conducted. The results obtained could be compared with previous results (including Technology Demonstration). In the event of an unfavourable comparison between the two sets of results, the cause of the irregularities should be determined.

A.4 System commissioning

Commissioning testing is performed prior to installing traffic on the system to ensure that the system meets its overall transmission performance contractual requirement, and that all functionalities with respect to the Network Management are operating. When extra margins are available at BOL, it is recommended to assess those one in order to track the ageing of the system.

If redundancy is used in the design to meet the reliability performance, redundant component could be used for correcting faults occurring during lay or prior to commissioning. However, the objective is to ensure that the number of redundant devices remaining available is sufficient to meet, with a high probability, the target for the number of ship repairs.

On completion of the System commissioning period, a continuous Transmission Segment out of service Confidence Trial should followed. Carefully controlled procedures should be established to prevent introduction of errors through human action. Any irregularity, variation alarm or non-routine event observed should be investigated.

A.5 Maintenance

A.5.1 Routine maintenance

Routine maintenance is performed from the terminal stations using the supervisory system. It consists in periodic monitoring of the system parameters and, when required, in preventive redundancy switching.

A.5.2 Maintenance at sea

Optical fibre submarine cable systems can be subject to faults due in particular to external aggression and to component failure. It is important to define and develop well-established and efficient repair procedures and equipment, to facilitate repair and limit loss of traffic.

Maintenance at sea is usually performed using dedicated repair cable ships.

A.5.2.1 Fault localization

For systems equipped with optical submarine repeaters, a first localization to within one supervisory section is obtained using the supervisory system.

For the end cable sections, cable fault localization may be achieved from the terminal stations, using adequate electrical measurement (resistance, capacitance, insulation, etc.) and optical reflectometry.

Similarly, cable fault localization may be achieved from the cable ship after cable recovery, using the same methods.

Electroding can be used to locate the cable route.

A.5.2.2 Cable recovery

During cable recovery it may be necessary, in order to limit the mechanical tension applied to the cable, to cut the cable on the sea bottom prior to recovering both ends separately.

A.5.2.3 Sea repair

Several methods can be used for sea repair according to the sea depth:

– the shallow water repair may necessitate the addition of a cable length, but not that of a repeater; a repair margin is generally included in the shallow water optical power budget since the shallow water sections are the most exposed at risk from external aggression, even though precautions are taken;

– the deep sea repair usually necessitates the addition of a cable length and sometimes of a repeater to compensate for the extra attenuation, if the extra attenuation incurred cannot be accommodated in the available margin; generally, a very low repair margin is included in the deep water optical power budget since deep sea repairs are not frequent.

When a fault is identified to within one supervisory section, the section may be replaced by a mini-system, without further localization. This method may save time, but requires more spare equipment.

Repair safety procedures are applied on board the cable ship and in the terminal station, so as to ensure the safety of the personnel operating on board the cable ship. In particular, power safety procedures involve earthing the cable in the terminal station, on board the cable ship and at branching unit.

APPENDIX I

Data on cable ships and submersible equipments of various countries

(Mar del Plata, 1968, amended at Geneva, 1972, 1976, 1980, 1984, 1988, 1955, ~~and~~ 2000 and 2004)

Section 1 – Cable ships

Name of ship	Year of construction	Displacement (tons)	Overall length (m)	Draft (m)	Normal speed (knots)	Range (autonomy) (nautical miles)	Number of tanks	Cable capacity: Cable: Cubic metres (m3)	Cable capacity: Cable: Weight (tons)	Cable capacity: Repeaters	Cable gear: Cable engine: Drum (diameter) (m)	Cable gear: Cable engine: Linear (pairs of wheels)	Cable gear: Unwinding pulley: Bow sheave (diameter) (m)	Cable gear: Unwinding pulley: Stern sheave (diameter) (m)	Maximum operating depth (m)	Capability
							DENMARK *Ships belonging to Tele Denmark*									
Peter Faber	1982	~~Open 750~~ ~~Closed 1830~~ 3680	~~78.4~~ 78.35	~~Open~~ Ice 3.8 ~~Closed~~ Summer 5.0	~~14.0~~ 13.0	7000	1 tank 1 hold	310 230	600 400	App. 10	3.0		2 x 3.0	–	4000	Reinforced for operation in icefilled waters. A-frame for ROV. Two hydraulic double-drum warping winches. ~~On the aft deck: one A-frame with hydraulic topping. Max. load 35 tons. One hydraulic towing and general purpose winch. Two hydraulic double-drum warping winches.~~
Maersk Fighter	1992/94	2961	82.5	6.24	15.7 Max	7700	2	1263	2400	24	4.0 (25t)	65 (4t)	4000	–	–	Laying/burying and repair of all types of cables (coaxial, optical fibre and power cables). Ploughs and ROV capability.
Heimdal	1982 / 2000	11493	136.7	6.60	15 Max	16000	4	4670	6224	>120	4.0 (25t)	20 (20t)	–	2 x 3.0	All	Laying/burying and repair of all types of cables (coaxial, optical fibre and power cables). Ploughs and ROV capability.
Maersk Defender	1996	~~8746~~ 11980	96.0	8.70	~~16 Max~~ 12	~~7700~~ 17000	4	~~3162~~ 3158	6000	~~>54~~ 12	4.0 (25t)	20 (20t)	~~8000~~	~~–~~ 2 x 3.0	~~–~~ All	Laying/burying and repair of all types of cables (coaxial, optical fibre and power cables). Ploughs and ROV capability.
Lodbrog	1985 / 2002	12503	143.4	8.50	16.0	10000	6	2940	5040	84	2 x 4.0 (25t)	2 x 6 (6t)	-	2 x 3.0	All	Laying/burying and repair of all types of cables (coaxial, optical fibre and power cables). ROV capability, SWL 8 ton.
							FINLAND *1) Ship belonging to Sonera LTD*									
M/S	1978	450	42.6	3.0	12	–	1	–	350	–	2 linear	3.0		300		Laying of all types of telecom cables.

Telepaatti	(modification)										engines with 3 caterpillar tracks on each					Specially equipped for cable route survey and cable repair. Fully automatic autopilot and DP-system.
							2) Ship belonging to YIT Primatel									
c/s Telepaatti	1978 modification 1999	450	42.6	3.0	10.5	-	1	250	260	-	-	2 linear engines with 3 caterpillar tracks on each	3.0	-	300	Laying of all types of telecom cables and <150 mm power cables. Specially equipped for cable route survey and cable repair. Fully automatic autopilot and DP-system.

Name of ship	**Year of construction**	**Displacement (tons)**	**Overall length (m)**	**Draft (m)**	**Normal speed (knots)**	**Range (autonomy) (nautical miles)**	**Number of tanks**	**Cable capacity: Cable: Cubic metres (m3)**	**Cable capacity: Cable: Weight (tons)**	**Cable capacity: Repeaters**	**Cable gear: Cable engine: Drum (diameter) (m)**	**Cable gear: Cable engine: Linear (pairs of wheels)**	**Cable gear: Unwinding pulley: Bow sheave (diameter) (m)**	**Cable gear: Unwinding pulley: Stern sheave (diameter) (m)**	**Maximum operating depth (m)**	**Capability**
							FRANCE ***1) Ships belonging to France Telecom***									
Vercors	1974	11 000	136	7.2	16.6	12 000	3	2425	4900	144	3.0	24	3.0	Chute	All	Laying and repair of all types of telecom cables. Burying of cables with plough.
Leon Thevenin	1983	6800	107	6.24	15.0	10 000	2 + 1	1420	2000	11	3.4	12	3.0	Chute	All	Laying and repair of all types of telecom cables. Burying of cables using Scarab.
Raymond Croze	1983	6800	107	6.24	15.0	10 000	2 + 1	1420	2000	11	3.4	12	3.0	Chute	All	Laying and repair of all types of telecom cables. Burying of cables using Scorpio 2000.
							2) Ships belonging to Alda Marine									
Ile de Sein Ile de Batz Ile de Brehat	2002	18006	140.4	8.016	15.0	15000	2 + 2	3000	5500	202	4.0	21	NA	3.0	All	Laying and repair of all types of telecom cables. Burying of cables with. 2/3m Rock plough. Sea state 7 A frame
Ile de Ré	1983 rebuilt 2002	12687	143.4	7.23	16.0	11000	3 + 3	2900	4500	84	2 x 4.0	NA	NA	3.0	All	Laying and repair of types of cable. No plough ROV to 2500m
							ITALY ***1) Ship belonging to Elettra TLC S.p.A***									

Teliri	1996	6500	111.5	6.5	~~15.0~~ 14.0	10 000	3	2000	2600	70	N.2 × 3.5	N.1 × 18wp	~~1 splitted~~ 3	~~1~~ 4	All	Laying and repair optical fibre systems ~~Laying and repair of armoured coaxial and optical fibre cables; survey.~~
Gertament (ex John Cabot)	1995 rebuilt ~~1999~~ 1998	~~5900~~ 5000	~~102~~ 96.6	7.3	~~13.5~~ 12.0	~~12 000~~ 8000	3	600	1900	24	N 1 × 3	1 × 18+ 1 × 6	3	3	All	Laying, survey and repair optical fibre systems
Pertinacia	2002	12650	129.9	8.4	14	10 000	2	4000	6400	2 x 100	N 1 x 4	1 x 20 1 x 6	–	3	All	Lay and repair optical ~~fiber~~fibre systems
							2) Ships belonging to Pirelli Cavi									
Arabella	1975	2620	76.66	5.18	11	2000	2	1100	2000	–		–	–	3	All	Lay/repair.
G.Verne	1984	16 900	128.5	8.5	10	8000	2	2600	8000	20	6.0 (50t)	1 (Pads type 10t)	–	6.0	All	Stern only.
							SPAIN ***Ships belonging to Tyco Submarine Systems Ltd.***									
Teneo	1992	4000	81	5.7	14.5	4200	2	500	1000	20	2 × 3.5	1 × 9	2 × 3	1 × 3	All	Lays and repairs of all types of telephone cables.
Atlantida	1987	7853	114	6.5	15.7	6800	3	1500	2500	33	2 × 3.5	1 × 12	2 × 3	1 × 3	All	Lays and repairs of all types of telephone cables.
Iberus	1978	10 000	136.03	6.6	12.5	13 500	3	2580	4000	108	1 × 3	1 × 20	–	2 × 3	All	Lays and repairs of all types of telephone cables.

Name of ship	**Year of construction**	**Displacement (tons)**	**Overall length (m)**	**Draft (m)**	**Normal speed (knots)**	**Range (autonomy) (nautical miles)**	**Number of tanks**	**Cable capacity**			**Cable gear**				**Maximum operating depth (m)**	**Capability**
								Cable		**Repeaters**	**Cable engine**		**Unwinding pulley**			
								Cubic metres (m3)	**Weight (tons)**		**Drum (diameter) (m)**	**Linear (pairs of wheels)**	**Bow sheave (diameter) (m)**	**Stern sheave (diameter) (m)**		
							JAPAN ***1) Ships belonging to Kokusai Cable Ship (KCS)***									
KDD Ocean Link	1992	11 700	133.2	7.0	15	10 000	Main 3 Spare 4	2320	4500	100	3.6	21	3.2	4.0	All	Laying by linear engine. Lays and repairs all types of submarine cables.
KDD Pacific Link	1997	–	109.0	7.5	12	–	Main 2 Spare 2	2720	4500	–	3.6	20	–	3.0	All	Laying by linear engine. Lays and repairs all types of submarine cables.

							2) Ships belonging to NTT World Engineering Marine Corporation (NTT-WE Marine)									
NTT Kuroshio Maru	1974	5656	119.3	5.60	16.5	6883	3	1429	1900	95	3.8	8 (24 inch)	3.0	3.0	All	Lays and repairs all types of telephone cables.
Subaru	1999	9557	123.3	7.0	13.2	8800	Main 2 Spare 2	2770	4000	50	4.0	21	–	3.2	All	Lays and repairs all types of telephone cables.
							UNITED KINGDOM *1) Ship belonging to British Telecommunications plc*									
Sovereign	1991	13 018	131	7.0	13.5	14 000	4	2800	6200	90	3.50		3.00	3.50	All	Lays, repairs all types of coaxial and optical fibre cable. (Operated by C&W marine.)
							2) Ships belonging to Global Marine Systems Ltd ~~Cable & Wireless (Marine) Limited~~									
Alert	1961	9477	130	7.1	14	10 000	3	1509	3100	48	2.98		2.98	2.98	All	Laying by linear engine and sea-bed burial by plow. Lays/repairs all types of coaxial and optical fibre cables.
Cable Venture	1962	16 983	153	8.97	12.5	10 000	4 + 1 (spare)	5086	9000	400	2.80		3.00	3.39	All	Laying by linear cable engine. Ploughs, lays and repairs armoured and lightweight cables.
Mercury	1962	11 683	144	7.5	14.5	8000	3	2970	3500	144	3.05		3.50	Chute 3.05	All	Ditto (no plough).
Cable Enterprise	1964	5759	113	5.84	13	8000	3	887	2150	30	2.8		3.00	Chute 3.05	All	Lays/repairs armoured cables. Repairs lightweight cables. (Note)
Monarch	1975	4639	97	5.5	14	7000	4	417	850	12	3.00		3.00	None	All	Lays/repairs armoured coaxial and optical fibre cables. Repairs lightweight coaxial and optical fibre cables. Detrenching/reburial by submersible jetting.

Name of ship	Year of con-struc-tion	Dis-place-ment (tons)	Overall length (m)	Draft (m)	Normal speed (knots)	Range (auto-nomy) (nautical miles)	Number of tanks	Cable capacity			Cable gear				Maximum operating depth (m)	Capability
								Cable		Re-peaters	Cable engine		Unwinding pulley			
								Cubic metres (m3)	Weight (tons)		Drum (diameter) (m)	Linear (pairs of wheels)	Bow sheave (diameter) (m)	Stern sheave (diameter) (m)		
							UNITED KINGDOM *2) Ships belonging to Global Marine Systems Ltd ~~Cable & Wireless (Marine) Limited~~*									

Iris	1976	4639	97	5.5	14	7000	4	417	850	12	3.00		3.00	None	All	Lays/repairs armoured coaxial and optical fibre cables. Repairs lightweight coaxial and optical fibre cables.
MV Cable Installer	1980	6065	89.42	5	12	42 days	4	840	1600	None	3.0	4-track pair	–	3.0	–	Repeaterless installation vessel fully DP Cegelec 901 system.
Seaspread	1980	10 887	116	6.8	13	65 days	2	1010	1701	–	2 × 3	–	–	3	All	Lays/repairs by aft drums. Burial by plough. Lays/repairs armoured and lightweight cables.
Pacific Guardian	1984	7526	116	6.32	14.0	8000	3	1416	3470	96	3.5		3.00	3.00	All	Laying by linear cable engine. Lays and repairs armoured and lightweight cables.
Sir Elic Sharp	1988	7526	115	6.3	13.5	9600	3	1416	1700	96	2 × 3.5	–	3	3	All	Laying by linear cable engine. Repairs and lays armoured and lightweight cables. Post lay/repair burial by integral ROV.
MV Cable Innovator	1995	–	142	8.3	14.5	42 days	4	4900	7500	180	4.0	21 pair (min)	–	4.0	–	Simplex *D/P* system. Lays/repairs cables.
							MARSHALL ISLANDS ***Ship belonging to Tyco Submarine Systems Ltd.***									
CS Coastal Connector	1997 Converted in 1996	6761	92.47	7.1	12.5	25 000	3 main 1 spare	675 (main, total) 70 (spare)	1600	30	2 × 3	N/A	N/A	2 × 3	–	The CS Coastal Connector is stern laying design. She is capable of deploying the SCARAB II, SCARAB IV, and Pacific SCARAB I ROV's, as well as the Seabed Tractor
CS Tyco Provider	1978, Converted in 1999	14 500	139.4	7.6	14.5	20 000	5	3349	6000	100+	2 × 4	–	–	2 × 3	–	The CS Tyco Provider is a stern laying design. She is capable of deploying Sea Plow VIII.
							NETHERLANDS ANTILLES ***Ship belonging to Tyco Submarine Systems Ltd. (charterer)***									
Dock Express 20	1983	21 731	169.52	8.79	12.5	20 500	3 main 2 spare	4050 (main, total) 640 (spare, total)	10 000	100+	1 × 3.0	1 × 3 module belt type	N/A	2 × 3		The Dock Express 20 is a stern laying design. She is capable of deploying the SCARAB II ROV, as well as the Seabed Tractor and Sea Plow VI.

Name of ship	**Year of con-**	**Dis- place-**	**Overall length**	**Draft (m)**	**Normal speed**	**Range (auto-**	**Number of**	**Cable capacity**		**Cable gear**		**Maximum operating depth**	**Capability**
								Cable	**Re-**	**Cable engine**	**Unwinding pulley**		

	struc- tion	ment (tons)	(m)		(knots)	nomy) (nautical miles)	tanks	Cubic metres (m3)	Weight (tons)	peaters	Drum (diameter) (m)	Linear (pairs of wheels)	Bow sheave (diameter) (m)	Stern sheave (diameter) (m)	depth (m)	
							UNITED STATES OF AMERICA *Ships belonging to AT&T*									
CS Charles L. Brown	1954, Reflag-ged in 1985	4298	99.94	5.6	13	7550	3	660	1186	30+	2 × 3	N/A	2 × 3	N/A	–	The Charles L. Brown is primarily a repair ship. She is not fitted with any stern laying equipment. She is capable of deploying the SCARAB II ROV.
CS Global Link	1990	16 375	145.7	8.08	15	10 000	3 main, 4 spare	3258 (main, total) 164 (spare, total)	6098	100+	2 × 3.7	1× Wester n Gear Tractor Type	2 × 3	1× trough/ Chute type	–	The Global Link is capable of deploying the SCARAB II ROV's.
CS Global Mariner	1993	15 638	151.5	7.8	13.8	10 000	2 main, 3 spare	2172 (main, total) 447 (spare, total)	4999	80+	2 × 3.7	1× Dowty 21 pair	2 × 3	1× trough/ Chute type	–	The Global Mariner is capable of deploying the SCARAB II and SCARAB IV ROV's, as well as Sea Plow VII, Sea Plow VIII, and the Seabed Tractor.
CS Global Sentinel	1991	16 375	145.7	8.08	15	10 000	3 main, 4 spare	3258 (main, total) 164 (spare, total)	6098	100+	2 × 3.7	1× Dowty 21 pair	2 × 3	1× trough/ Chute type	–	The Global Sentinel is capable of deploying the SCARAB II and SCARAB IV, and Pacific SCARAB I ROV's, as well as Sea Plow VII and Sea Plow VIII.
NOTE – Only relatively short cables are laid and only shore-end.																

Section 2 – Submersible equipments

Type of submersible	Weight (tons)	Overall length (m)	Width (m)	Height (m)	Trenching system	Trenching	Propulsion	Max.operating depth (m)	Capability
				FRANCE *Submersibles belonging to France Telecom (FTRSI)*					
ELISE2 Submersible Plough system	17	7.60	2.90	2.95	Ploughshare	Immediate burial up to 1.1 m	Towed by support ship	1500	Lay and bury all types of cables.
ELISE3 Submersible Plough system	17	7.60	2.90	2.95	Ploughshare	Immediate burial up to 1.1 m	Towed by support ship	1500	Lay and bury all types of cables.

Self-advancing buried system CASTOR2	12	7.0	2.40	3.00	Trenching wheel or chain	Burial of existing cables down to 2 m	Tracked vehicle	1000	Burial of cables and pipes. Visual inspection.
Scarab 3	9	4.0	3.50	2.10	High pressure water jets	Up to 60 cm depth	Thrusters (inspection) Back drive (burial)	1000 (burial) 2000 (inspect)	Visual inspection, post lay burial, cable location, cable manipulation, cable cutting.
Remote control submersible Scorpio 2000	3.4	2.9	1.5	2.11	High pressure water jets	Up to 60 cm depth	Thrusters	1000	Visual inspection, post lay burial, cable location/ manipulation/cutting.
					ITALY ***1) Submersibles belonging to Elettra TLC SpA***				
Plough Taurus 1	14	9	4.6	4.5	Plough share	Up to 1 mt	***Plough Taurus 1***	14	9
Plough Taurus 2	16	9.5	4.5	5.1	Plough share	Up to 1.5 mt	***Plough Taurus 2***	16	9.5
ROV – Phoenix 2	6.8	4.8	2	2.6	High/low pressure jetting	Up to 1.2 mt	***ROV – Phoenix 2***	6.8	4.8
					ITALY ***2) Submersibles belonging to Pirelli Cavi***				
Plough 1	10	7	2.7	3	Plough share	Up to 1 m	***Plough 1***	10	7
Plough 2	9	8.5	3.8	3.5	Plough share	Up to 1.2 m	***Plough 2***	9	8.5
					UNITED KINGDOM ***Submersibles belonging to Global Marine Systems Ltd~~Cable & Wireless (Marine) Ltd.~~***				
Submersible trencher	17.0	6.6	4	3.4	Fluidization and cutting jets and dredge pump	Up to 1 m depth with cutting and fluidization jets	Three vertical and four horizontal thrusters, track drive differential steering	274	Trench in existing cable and pipe.
Submersible Plough system	9.75	6.1	2.6	2.6	Ploughshare proceeded by disc	Immediate burial of cable on ploughing	Towed by support ship	900	Lay and bury cable, umbilical and pipe in one action giving full cable protection.
Remote control submersible 2 off Cirus A&B	3.2	3.5	2.1	2.3	Water jets	Trenching capability 0.3 m	Thrusters (7)	1000	Visual inspection, cable location/inspection/deburial, manipulation. Tools include cable cutter, cable gripper and 2 manipulators with

									line cutters.

Type of submersible	Weight (tons)	Overall length (m)	Width (m)	Height (m)	Trenching system	Trenching	Propulsion	Max.operating depth (m)	Capability
				UNITED KINGDOM *Submersibles belonging to* ***Global Marine Systems Ltd****~~Cable & Wireless (Marine) Ltd.~~*					
Plough 2 off A&B	14.5	9	4.1	4	Passive blade	Trenching capability 1.0 m	Towed	1000	Steerable, repeater burial.
Remote control submersible ROV 128	7.5	2.9	1.8	2.0	Jetting tool	Trenching capability 0.6 m	Tracked burial Thrusters survey	1000 (burial) 2000 (survey)	Tools include cable cutter, cable gripper and 2 manipulators with line cutters.
Underwater vehicle-MARLIN	7.8	4.191	2.438	3.175	Burial skid	To 1.0 m (Optimized for 0-30 kPa soil)	Hydraulic driven thrusters	2500	Burial, deburial, inspection. Maintenance and repair. Tools include cable cutter, cable gripper.
Scarab I – Umbilically tethered ROV	3.2	2.74	1.82	1.52	Jetting tool	Up to 0.6 m	Thrusters: 2 vertical 4 vectored	2000	Cable detection and inspection. Visual survey. Cable manipulation and cutting Debris elimination. Cable and repeater burial/ deburial.
Subtrack - ROV	10.0	8.0 (Max)	3.7	3.8	Jetting tool	Burial to 1.0 m	Electro hydraulic track drives	1000	Cable burial and deburial. Inspection. Maintenance and repair.
EUREKA: Deepwater burial + trenching system	17 (Max)	5.5	4.2	3.85	Jetting tool Rock wheel cutter Mechanical chain excavator	1 m 1.2 m 2.2 m	Electro hydraulic track drives	1500	Capable of burying cable, small flexible flowlines and also rigid pipes. Can also debury cable and restore. Visual and electronic inspections.
Plough 5	14.0	9.0	4.6	3.7	Passive blade	Variable from 0-1100 mm (600-900 mm in all conditions)	Towed	1000	Simultaneously lay and bury cables and umbilicals at varying depths.
Plough 6 and 7	14.0	9.0	4.6	3.7	Passive blade	Max burial depth: 1100 mm	Towed	1000	Simultaneously lay and bury cables and umbilicals at varying depths.
Cable Plough 1000 mm	14.4	9.75	4.1	3.9	Passive blade	1000 mm (Good conditions:	Towed	1000	Simultaneously lay and bury cables and umbilicals at varying

						1100 mm; Repeaters/Joints: 500 mm)			depths.

Type of submersible	Weight (tons)	Overall length (m)	Width (m)	Height (m)	Trenching system	Trenching	Propulsion	Max.operating depth (m)	Capability
				DENMARK *Submersibles belonging to Telecom Denmark*					
Plough D	13.5	9.0	4.6	3.7	Plough share	Variable from 0-1100 mm (600-900 mm in all conditions)	Towed by host vessel	1500	Lay and bury telecom cables, power cables and umbilicals. Cables: Up to 120 mmϕ (bary). Joints and repeaters: Up to 400 mmϕ (pass).
Plough 7	13.5	9.0	4.6	3.7	Plough share	Variable from 0-1100 mm (600-900 mm in all conditions)	Towed by surface vessel	1000	Lay and bury fibre optic cables, power cables and umbilicals.
Subtrack- Subsea tractor	10.0	8.0 (Max)	3.7	3.8	Jetting tool	Burial to 1.0 m	Electro hydraulic track drives	1000	Cable burial and deburial. Inspection. Maintenance and repair.
Super Phantom S4-ROV	0.09	1.5	0.75	0.6	–	–	Thrusters 4 prop fwd/aft 2 prop vertical 2 prop transvers	300	Inspect cables and other underwater objects. Can also be used to inspect seabed conditions.
				JAPAN ***1) Submersibles belonging to KCS***					
MARCAS-II-ROV	Jet tool mode: 8.0 Track base mode: 7.5	Jet tool mode: 2.9 Track base mode: 5.3	Jet tool mode: 2.3 Track base mode: 4.0	Jet tool mode: 3.2 Track base mode: 3.8	Water jet tool	–	4 horizontal, 2 vertical and 2 balance thrusters	Jet tool mode: 2500 Track base mode: 2000	Post-lay burial, maintenance of cable. Can survey seabed.
MARCAS-SBT-ROV	15 (minimum) 23 (maximum)	Jet tool mode: 9.5 Chain cutter mode: 13.0 Wheel cutter mode:	Jet tool mode: 5.5 Chain cutter mode: 5.5 Wheel cutter mode: 5.5	Jet tool mode: 4.4 Chain cutter mode: 4.4 Wheel cutter mode: 4.4	2.1 m Rear jet tool and 1 m Forward jet tool 1.2 m Wheel cutter 3 m Chain cutter		One single hydraulic thruster	1500	Lay and burial, post-lay burial, maintenance of cable, and survey of seabed.

		12.0							

Type of submersible	Weight (tons)	Overall length (m)	Width (m)	Height (m)	Trenching system	Trenching	Propulsion	Max.operating depth (m)	Capability
				JAPAN *2) Submersibles belonging to NTT-WE Marine*					
Plough-type MARK-5 submarine cable burying system	19.0	9.1	4.0	4.0	–	Up to 1.5 m depth immediate burial of cable on ploughing	Towed by support ship	600	Simultaneous or post-lay burial of cable.
Submarine cable repair burial and inspection system	6.2	3.8	2.1	2.3	Fluidization jets	Fluidization jets	Vertical and horizontal thrusters	1000	Post-lay burial maintenance of cable and survey of seabed.
Plough-type MARK-6 submarine cable burying system	18	9.3	5.1	4.4	–	Up to 2.0 m depth immediate burial of cable on ploughing	Towed by support ship	1500	Simultaneous or post-lay burial of cable.
Submarine cable repair burial and inspection system	8.0	3.2	2.1	2.8	Fluidization jets	Trenching capability 1.0 m	Vertical and horizontal thrusters	2500	Cable detection & inspection visual survey. Cable manipulation & cutting. Debris stockage. Cable & repeater burial/deburial.
SEA MOLE Tractor type Submarine cable Burial system	23	8	6	3.5	3 types attachment (jetting tool, wheel cutter & chain cutter)	Trenching capability 2.0 m (max.)	–	1000	
				SPAIN ***1) Submersible belonging to Tyco Submarine Systems Ltd.***					
ARADO I	12	9	4.6	4	Plow-share	1100 mm	Towed	1500	Bury cable from 19 to 40 mm. Bury repeaters until 380 mm. Velocity 1 m/s.
ARADO II	12	9	4.6	4	Plow-share	1500 mm	Towed	1500	Bury cable from 17 to 150 mm. Bury repeaters until 380 mm. Velocity 1 m/s.
ARDI	3.6	6.1	3	2.6	Plow-share	900 mm	Towed	1500	System to evaluate if land is arable.
NEREUS	8.5	3.2	3.4	2.9		1 m	150 KW	2000	Repair, inspect and bury all types of telephone cable 2 × manipulating 7 functions.

									Velocity 3 knots.

Type of submersible	**Weight (tons)**	**Overall length (m)**	**Width (m)**	**Height (m)**	**Trenching system**	**Trenching**	**Propulsion**	**Max.operating depth (m)**	**Capability**
				SPAIN *1) Submersible belonging to Tyco Submarine Systems Ltd.*					
SCARAB III	8.5	4	3.9	2.1		0.6	180 KW	2000	Repair, inspect and bury all types of telephone cable 2 x manipulating 7 functions. Velocity 3.1 knots.
				2) Submersible belonging to Consorcio ESCARAB					
ROV	8.5	4.0	3.9	2.1		Up to 1 m		2000 1000	
				UNITED STATES OF AMERICA ***Submersibles belonging to Tyco Submarine Systems Ltd.***					
PACIFIC SCARAB I	5.48	4.27	1.83	3.05	Jetting Modules	560 meters/hour. Soil hardness to 100 kPa.	150HP Electro Hydraulically Powered using 8 thrusters	2500	PACIFIC SCARAB I Submersible Craft Assisting Repair and Burial is a tethered, swimming ROV capable of operating at depths of 2500 meters. It can locate, inspect, retrieve, and bury submarine cables.
SCARAB II	3.45	3.7	2.1	2.3	35 HP Cable Jetter	255m/hr depending on soil conditions. Soil hardness to 60 kPa.	Horizontal: 4×5 HP Electric Thrusters Vertical: 2×5 HP Electric Thrusters Aft Lateral: 1×10 HP Hydraulic Thruster Bow: 2×2.5 HP Hydraulic Thrusters	1850	SCARAB II Submersible Craft Assisting Repair and Burial is a tethered, swimming ROV capable of operating at depths of 1850 meters. It can locate, inspect, retrieve, and bury submarine cables.

Type of submersible	Weight (tons)	Overall length (m)	Width (m)	Height (m)	Trenching system	Trenching	Propulsion	Max.operating depth (m)	Capability
				UNITED STATES OF AMERICA *Submersibles belonging to Tyco Submarine Systems Ltd.*					
SCARAB IV	4.6	3.4	2.02	1.96	Jetting Modules	530 meters/hour Soil hardness to 100 kPa	150 HP Electro-Hydraulically Powered using 8 thrusters	1850	SCARAB IV Submersible Craft Assisting Repair and Burial is a tethered, swimming ROV capable of operating at depths of 1850 meters. It can locate, inspect, retrieve, and bury submarine cables. SCARAB IV is part of the ACMA SCARAB Agreement.
Sea Plow VI	25.5	10.5	6.0	4.3	Towed Plow System	1.2 meter burial	Towed by ship	1000	Sea Plow VI is a towed burial tool employing state-of-the-art burial features. It can achieve 1.2 meter burial depth in up to 1000 meter water depth.
Sea Plow VII	14.0	10.5	6.0	4.3	Towed Plow System	1.0 meter burial	Towed by ship. 1 Thruster for Launches and Recoveries	1400	Sea Plow VII is a towed burial tool employing state-of-the-art burial features. It can achieve 1.0 meter burial depth in up to 1400 meter water depth.
Sea Plow VIII	19.3	9.2	5.5	3.6	Towed Plow System with water jet assist	1.5 meter burial	Towed by ship	1500	Sea Plow VIII is a towed burial tool employing state of the art burial features. It can achieve 1.5 meter burial depth in up to 1500 meter water depth.