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

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

Definition of terms relevant to optical fibre submarine cable systems

Recommendation ITU-T G.972

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Recommendation ITU-T G.972

Definition of terms relevant to optical fibre submarine cable systems

Summary

Recommendation ITU-T G.972 applies to optical fibre submarine cable systems. The purpose of this Recommendation is to provide definitions of terms relevant to optical fibre submarine cable systems, including terms relevant to system configuration, system aspects, terminal equipment, optical submarine repeaters and branching units, optical fibre submarine cable, manufacturing and installation, and the maintenance of the submarine portion. Appendix I is the alphabetical list of terms defined in this Recommendation.

History

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Recommendation ITU-T G.972

Definition of terms relevant to optical fibre submarine cable systems

1 Scope

The purpose of this Recommendation is to provide definitions of terms relevant to optical fibre submarine cable systems.

A small number of terms defined in this Recommendation are associated with definitions in [ITU-T G.601], [ITU-T G.602] and [ITU-T G.701]. References to these definitions are given in parenthesis as an aid to ensure consistency between the different Recommendations in the event of future amendments.

Figure 1 of [ITU-T G.971] 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 of [ITU-T G.971], 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. Letters in brackets in the definitions of this Recommendation refer to the above figure.

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; 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 does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.601] Recommendation ITU-T G.601 (1988), *Terminology for cables*.

[ITU-T G.602] Recommendation ITU-T G.602 (1988), *Reliability and availability of analogue cable transmission systems and associated equipments*.

[ITU-T G.652] Recommendation ITU-T G.652 (2016), *Characteristics of a single-mode optical fibre and cable*.

[ITU-T G.653] Recommendation ITU-T G.653 (2010), *Characteristics of a dispersion-shifted, single-mode optical fibre and cable*.

[ITU-T G.654] Recommendation ITU-T G.654 (2020), *Characteristics of a cut-off shifted, single-mode optical fibre and cable*.

[ITU-T G.655] Recommendation ITU-T G.655 (2009), *Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable*.

[ITU-T G.656] Recommendation ITU-T G.656 (2010), *Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport*.

[ITU-T G.701] Recommendation ITU-T G.701 (1993), *Vocabulary of digital transmission and multiplexing, and pulse code modulation (PCM) terms*.

[ITU-T G.870] Recommendation ITU-T G.870/Y.1352 (2016), *Terms and definitions for optical transport networks.*

[ITU-T G.872] Recommendation ITU-T G.872 (2019), *Architecture of optical transport networks.*

[ITU-T G.957] Recommendation ITU-T G.957 (2006), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy.*

[ITU-T G.971] Recommendation ITU-T G.971 (2020), *General features of optical fibre submarine cable systems.*

[ITU-T G.976] Recommendation ITU-T G.976 (2014), *Test methods applicable to optical fibre submarine cable systems*.

[ITU-T G.977] Recommendation ITU-T G.977 (2015), *Characteristics of optically amplified optical fibre submarine cable systems*.

[ITU-T G.977.1] Recommendation ITU-T G.977.1 (2020), *Transverse compatible DWDM applications for repeatered optical fibre submarine cable systems.*

[ITU-T G.979] Recommendation ITU-T G.979 (2016), *Characteristics of monitoring systems for optical submarine cable systems.*

3 Definitions

This Recommendation defines the following terms:

3.1 Terms relevant to elements of system configuration

1001 optical fibre submarine cable system: A set of equipment designed to permit the interconnection of two or more terminal stations.

The optical fibre submarine cable system is usually composed of terminal equipment (terminal transmission equipment, power feeding equipment, maintenance controller, etc.), and submersible equipment (cable, repeater(s), branching unit(s), etc.).

1002 optical fibre submarine cable link: A link which interconnects two terminal stations using a single optical fibre submarine cable system or an integrated system using system portions supplied by different suppliers.

1003 optical fibre submarine cable network: A network which interconnects three or more terminal stations using a single optical fibre submarine cable system or an integrated system made of system portions supplied by different suppliers.

1004 land portion: The portion between the system interface in the terminal station (A), and the beach joint or landing point (B) when it exists. It includes the optical fibre land cable, land repeaters, land joints and the system terminal equipment.

1005 submarine portion: The portion of the system laying on the seabed, between the beach joints or landing points (B), which includes the optical fibre submarine cable and the submarine equipment (e.g., optical submarine repeater(s), optical submarine branching unit(s) and optical submarine cable jointing box(es)).

1006 beach joint: The cable joint made between the optical fibre submarine cable and the optical fibre land cable.

1007 terminal station: The telecommunication station usually located in the vicinity of the landing point and housing the optical fibre submarine cable system terminal equipment and that of associated terrestrial systems.

1008 terminal station equipment (TSE): The TSE comprises the system terminal equipment (STE) and the ancillary equipment used for the operation of the optical fibre submarine cable system.

1009 system terminal equipment (STE): The STE comprises all equipments specific to a given optical fibre submarine cable system.

1010 terminal transmission equipment (TTE): The equipment terminating the optical submarine transmission line at the optical interface and connected to the system interface. The TTE may have multiple signal sources with channel multiplexer/demultiplexer. For interoperable submarine cable systems, TTE is treated as the terminal portion, and terminates the interoperable cable section.

1011 supervisory system: The whole of equipment and sub-assemblies commonly providing one or more of the following functions:

– monitoring the performance of the submarine equipment and sub-assemblies;

– monitoring the performance of the system terminal equipment;

– monitoring the end-to-end performance of the digital line sections;

– enabling fault location inside the submarine plant, to within one repeater section, where possible;

– controlling redundancy switching, if provided inside the submarine portion;

– providing interfaces to other management facilities.

1012 maintenance controller: A computer with an interface to the supervision and remote maintenance equipment, which is commonly used during the supervision and remote maintenance activity for the equipment in the submarine portion. It is also used for terminal transmission equipment (TTE) maintenance purposes.

1013 power feeding equipment (PFE): The equipment providing, through a power conductor in the optical fibre submarine cable, a stabilized constant electrical current for powering optical submarine repeaters and/or optical submarine branching units.

1014 cable terminating equipment (CTE): The equipment providing the interface between the optical fibre from the terminal transmission equipment (TTE) and the optical fibre cable, and the interface between the power feeding line from the power feeding equipment (PFE) and the power feeding conductor from the optical fibre cable.

NOTE – The CTE is usually part of the PFE.

1015 power feed earth: The earth provided to establish the return path of the repeater power feeding current circuit.

1016 power feed earth electrode cable: The cable installed between the power feed earth and the power feeding equipment (PFE).

1017 optical fibre station cable: The optical fibre cable installed inside the cable station.

1018 optical fibre land cable: The optical fibre cable installed between the cable terminating equipment (CTE) and the beach joint.

1019 optical fibre submarine cable: The submarine cable using optical fibres as transmission line.

1020 optical submarine repeater: (Related to definition 1001 provided in [ITU-T G.601]) An equipment essentially including one or more regenerators or amplifiers and associated devices, in the submarine portion.

1021 bipolar repeater: An optical submarine repeater which can be powered by a power feeding current flowing in either direction.

1022 branching unit (BU): An equipment connecting more than two optical fibre submarine cable sections.

NOTE – Applications for the optical submarine branching may include the following additional functions:

– optical signal path switching;

– signal regeneration or amplification;

– power path switching.

1023 undersea branching multiplexer (UBM): A branching unit that separates lower level digital signals from incoming optical line signals and recombines them differently in outgoing optical line signals.

1024 integration specification: A set of specifications established to permit the interconnection of two or more optical fibre submarine cable systems designed by different suppliers.

1025 integration line optical interface: The optical interface between fractions of the submarine cable sections provided by different suppliers.

1026 shallow water: Water depths down to a given limit, corresponding to the depths of fishing activity, or more generally of marine activity, creating a risk of cable fault.

NOTE – The limit of shallow water is of the order of 1000 metres.

1027 deep water: Water depths exceeding the limit of shallow water.

1028 elementary cable section: The whole length of optical fibre cable between two pieces of equipment (repeaters, branching units or terminal transmission equipment).

1029 repeatered submarine cable: An electrically powered underwater optical fibre cable, designed for repeatered applications, and suitable for shallow and deep water use, which has been extensively tested to show it can be installed and repaired *in situ*, even in the worst weather conditions, without any impairment of optical, electrical or mechanical performance or reliability.

NOTE – For appropriate test methods, please refer to [ITU-T G.976].

1030 repeaterless submarine cable: An underwater optical fibre cable, designed for unrepeatered applications, and suitable for shallow and deep water use, which has been extensively tested to show it can be installed and repaired *in situ*, even in the worst weather conditions, without any impairment of optical, electrical or mechanical performance or reliability.

NOTE 1 – For appropriate test methods, please refer to [ITU-T G.976].

NOTE 2 – The term "repeaterless" is also known as "unrepeatered" or "non-repeatered".

1031 marinized terrestrial cable (MTC): An underwater optical fibre cable construction based on a conventional multi-fibre terrestrial cable core protected to withstand the marine environment, designed for unrepeatered applications and tested for use in non-aggressive shallow waters with varying repair capability.

NOTE 1 – Sometimes known in Europe as an "underwater" cable.

NOTE 2 – Appropriate test methods are under study.

1032 single wavelength system (SWS): A bidirectional optical system that carries on only one line optical channel (LOC).

1033 wavelength division multiplexing (WDM): An aggregate of several line optical channels (LOCs) to be carried through part or the whole of the submarine line on the same line fibre.

1034 wavelength division multiplexing system (WDMS): A bidirectional optical system that carries on several line optical channels (LOCs).

1035 dense wavelength division multiplexing (DWDM): An aggregate of a large number of line optical channels (LOCs) to be carried through part or the whole of the submarine line on the same line fibre.

1036 dense wavelength division multiplexing system (DWDMS): A bidirectional optical system that carries on a large number of line optical channels (LOCs).

1037 gain equalizer: Gain equalizer is the means used to adapt the submerged plant gain profile characteristics suitable for transmission.

1038 tilt equalizer: Tilt equalizer is the means for wavelength division multiplexing system (WDMS) to provide the equalization of the residual gain/wavelength tilt which accumulates when the signal is transmitted through a chain of submerged repeaters.

1039 slope equalizer: Slope equalizer is the means for wavelength division multiplexing system (WDMS) to provide the equalization of the residual gain/wavelength slope which accumulates when the signal is transmitted through a chain of submerged repeaters.

1040 shunt fault: A shunt fault is a current leakage path between the power conductor and the sea water without a break in the power conductor.

1041 remote optically pumped amplifier (ROPA): An optical fibre amplifier (OFA) consisting of a section of erbium doped fibre that is activated by a pump beam sent from the terminal station.

1042 distributed Raman amplifier (DRA): An optical fibre amplifier (OFA) using the transmission fibre as an amplifier medium that is pumped from the terminal station. The gain is obtained all along the fibre (therefore distributed) using the Raman properties of the fibre until sufficient pump power is available.

1043 Raman gain coefficient: For further study.

1044 elementary cable: A series of elementary cable sections.

1045 single-fibre type elementary cable: Elementary cable consisting of a single type of optical fibre.

1046 hybrid-fibre type elementary cable: Elementary cable consisting of more than one type of optical fibre.

1047 cut-off shifted single-mode fibre (CSF): Loss-minimized and cut-off shifted single-mode optical fibre, specified in [ITU-T G.654].

1048 dispersion compensating single-mode fibre (DCF): Single-mode optical fibre with large negative chromatic dispersion value.

1049 dispersion shifted single-mode fibre (DSF): Zero-dispersion wavelength shifted single-mode optical fibre, specified in [ITU-T G.653].

1050 large effective area single-mode fibre (LEF): Single-mode optical fibre with enlarged effective area.

1051 negative dispersion single-mode fibre (NDF): Single-mode optical fibre with negative chromatic dispersion value in the signal wavelength region.

1052 non-zero dispersion shifted single-mode fibre (NZDSF): Zero-dispersion wavelength shifted single-mode optical fibre, but it has some non-zero chromatic dispersion value in the wavelength region of 1530 to 1565 nm, specified in [ITU-T G.655].

1053 positive dispersion single-mode fibre (PDF): Single-mode optical fibre with positive chromatic dispersion value in the signal wavelength region.

1054 non-dispersion shifted single-mode fibre (SMF): Single-mode optical fibre, which has a zero-dispersion wavelength in the 1310 nm wavelength region, specified in [ITU-T G.652].

1055 wideband non-zero dispersion single-mode fibre (WNZDF): Single-mode optical fibre, which has some non-zero chromatic dispersion value in the wavelength region of 1460 to 1625 nm, specified in [ITU-T G.656].

1056 optical transport network (OTN): Optical network, which is composed of a set of optical network elements connected by optical fibre links, able to provide functionality of transport, multiplexing, routing, management, supervision and survivability of optical channels carrying client signals, according to the requirements given in [ITU-T G.872] (see [ITU-T G.870]).

1057 optical transport hierarchy (OTH): A hierarchical set of digital transport structures, standardized for the transport of suitably adapted payloads over optical transmission networks (see [ITU-T G.870]).

1058 optical submarine equalizer (OSE): Submerged equipment used to compensate for, or to handle, the accumulative gain ripple and tilt along a submarine digital line section (SDLS) in order to be compliant with the pre-emphasis capability of the terminal transmission equipment (TTE) at the transmitter side, and with the corresponding impairment allocated in the power budget table.

1059 longitudinal compatibility: The arrangement where both ends of an optical section are terminated by equipment from the same manufacturer (see [b-ITU-T G-Sup.39]).

1060 transverse compatibility: The capability to mix various manufacturers' equipments within a single optical section (see [ITU-T G.957]).

1061 electrical command response (ECR): The equipment providing communication functions with the equipment in the submarine portion such as repeaters and branching units to control them and receive the monitoring data from the equipment.

1062 optical coupling junction (OCJ): The equipment connecting the monitoring related equipment and providing functions to forward the monitoring signals to the submarine cable section together with the signals from the terminal transmission equipment (TTE). It can be either a passive or active coupling device and may include a bandwidth multiplexer/demultiplexer and/or amplifier to accommodate the wave division multiplexing (WDM) signals from multiple TTEs.

1063 terminal portion: The portion between the system interface in the terminal station (A, refers to Figure 1 in [ITU-T G.971]), and the interoperable system interface for an interoperable submarine cable system (C, refers to Figure 1 in [ITU-T G.971]), which is a joint point between the terminal transmission equipment (TTE) and the optical coupling junction (OCJ). It includes TTE and MC for TTE.

1064 interoperable cable portion: The portion of the system between the joint points (C), which includes optical coupling junctions (OCJs), other maintenance related equipment (MC, ME, ECR or PFE), the optical fibre submarine cable and the submarine equipment (e.g., optical submarine repeater(s), optical submarine branching unit(s) and optical submarine cable jointing box(es)). It may include the land repeaters and optical fibre land cable when the system has a repeatered land cable section.

1065 land repeater: (Related to definition 1001 provided in [ITU-T G.601]) An equipment essentially including one or more amplifiers and associated devices, in the land portion.

3.2 Terms relevant to system aspects

2001 system design life: The period of time over which the optical fibre submarine cable system is designed to operate in conformance with its performance specification.

2002 optical power budget: The allocation of the available optical power in an optical section.

2003 digital line section: (Related to definitions 3007 and 3012 provided in [ITU-T G.701]) The whole of the means of transmission of a digital signal at a specified bit rate between the corresponding input and output system interfaces at the digital distribution frame or equivalent. A digital line section forms a part of a digital link and includes terminal equipment, repeaters and branching units. The definition normally applies to the combination of "go" and "return" directions of transmission.

NOTE – This definition differs from the definition in [ITU-T G.701] as the latter excludes multiplexers. In an optical fibre submarine cable system, a digital line section is meant to include optical submarine branching multiplexers, if any, and also terminal multiplexing equipment included in the terminal transmission equipment (TTE) which may include multiplexing.

2004 optical section: The whole of the optical path as a physical transmission medium between the optical source output (point O) of one equipment and the optical detector input (point I) of the following equipment.

2005 optical source output: The point where the launched power is measured (point O).

2006 optical detector input: The point where the received optical power is measured (point I).

2007 supervisory section: The fraction of the submarine portion extending from one specified point in a repeater to a similar point in the adjacent repeater which can be identified using the supervisory system for fault location.

2008 system interface: (Related to definition 1008 provided in [ITU-T G.701]) The point (A) on the specified equipment, such as the digital distribution frame, at which each digital line section terminates. The interfaces are usually designated as I_i, pertaining to the incoming tributaries, and I_o, pertaining to the outgoing tributaries.

2009 optical interface: (Related to definition 1008 provided in [ITU-T G.701]) A common boundary between two associated parts of an optical section.

2010 transmit terminal optical interface: The optical interface at the output port (point S) of a transmit terminal equipment.

2011 receive terminal optical interface: The optical interface at the input port (point R) of a receive terminal equipment.

2012 repeater (or BU) optical output interface: The optical interface at the output port (point S) of a repeater (or BU).

NOTE – The output port is usually at the splice between the repeater fibre and the cable fibre.

2013 repeater (or BU) optical input interface: The optical interface at the input port (point R) of a repeater (or BU).

NOTE – The input port is usually at the splice between the repeater fibre and the cable fibre.

2014 optical line signal: The optical signal transmitted on one optical fibre in the submarine portion.

2015 line frame: (Related to definition 4007 provided in [ITU-T G.701]) A cyclic set of consecutive time slots in the optical line signal in which the relative position of each time slot can be identified.

NOTE – The line frame results from the multiplexing and coding operations performed by the terminal transmission equipment (TTE), taking into account the inclusion of the service and supervisory channels.

2016 system interface bit rate: (Related to definition 2013 provided in [ITU-T G.701]) The number of bits (binary digits) per unit time in the digital signal at the system interface.

NOTE – Several interface bit rates may coexist for one single optical fibre submarine cable system.

2017 line error ratio: The error ratio as could be observed using appropriate means at a given location in the submarine portion.

2018 apparent line error ratio: The value of the line error ratio obtained using the supervisory equipment of the submarine optical fibre cable system.

2019 electroding: The use of undersea equipment for the detection of a low frequency modulation of the power feeding current for cable location purposes.

2020 power feeding current: The stabilized electric current provided by the PFE through the cable power conductor with return through the power feed earth.

2021 line bit rate: (Related to definition 2014 provided in [ITU-T G.701]) The number of signal elements of the optical line signal per unit time.

NOTE – The line bit rate results from the multiplexing and coding operations performed by the terminal transmission equipment (TTE), taking into account the inclusion of the service and supervisory channel.

2022 line code: (Related to definition 9002 provided in [ITU-T G.701]) A code chosen to suit the characteristics of the submarine portion that defines the equivalence between sets of digits presented for transmission and the corresponding sequence of signal elements transmitted over that channel.

NOTE – The line code and violations of the line code can be used for system monitoring and supervisory.

2023 system performance penalty: A parameter included in the optical power budget to take into account phenomena such as chromatic dispersion, partition noise, etc.

2024 cable section margin: A parameter included in the optical power budget, to take into account the variation of the fibre attenuation due to ageing during the system design life.

2025 equipment margin: A parameter included in the optical power budget to take into account the variation of the optical power at both ends of a cable section due to equipment component ageing during the system design life.

2026 repair allowance: A parameter included in the optical power budget to take into account the possible increase of attenuation of the cable fibre due to cable repair during the system design life.

2027 unassigned margin: A parameter included in the power budget as a provision for unforeseen phenomena.

2028 guaranteed margin: The minimum margin in the power budget.

2029 overload margin: The minimum difference between the received power and the input power above which the bit error ratio would exceed a specified level.

2030 expected ship repair number: The mean number of repairs by cableship (statistical expectation) due to system failures during the system design life.

NOTE – This excludes faults due to external aggression.

2031 reliability budget: A reliability model indicating the reliability of each of the components of the submarine portion to be met so as to keep the expected ship repair number below a given limit.

2032 availability: (See the definitions provided in [ITU-T G.602]) The ability of the system to be in a state to perform adequately at a given instant of time within a given time interval. The availability of an optical fibre submarine cable system is quantified by the ratio of the time during which the system is operating to a specified total time.

NOTE – System interruptions due to faults requiring ship repair are excluded for availability calculation.

2033 end-to-end performance monitoring: The evaluation of the end-to-end transmission quality performance of each digital line section in the submarine optical fibre cable transmission system.

2034 supervisory of an optical fibre submarine cable system: The function provided by the supervisory system of the optical fibre submarine cable system so as to permit fault localization, repeater performance monitoring and remote-controlled redundancy switching.

2035 forward error correction (FEC): A technique which consists of transmitting the data in an encoded form such that the redundancy added by the coding allows the decoding to detect and correct errors.

2036 FEC frame: In frame-structured coding algorithms, the cyclic set of consecutive time slots delivered by the FEC encoder which, at a minimum, contains a frame alignment word, the data at system interface (A) and the redundant information computed with the FEC algorithm.

2037 Q factor: A measurement of the quality of the received signal (see [ITU-T G.976]).

2038 line optical channel (LOC): A bidirectional optical data channel carried on a specific optical frequency/wavelength for each transmission direction.

2039 submarine cable optical interface (SCOI): The bidirectional optical interface between the submarine cable including the terrestrial cable section and the terminal transmission equipment (TTE).

2040 LOC-TTE: A terminal transmission equipment (TTE) whose submarine cable optical interface (SCOI) is composed of only one line optical channel (LOC).

2041 WDM-TTE: A TTE equipped with WM and WD, whose submarine cable optical interface (SCOI) is a WDM.

2042 submarine electro-optic interface (SEOI): The bidirectional interface inside the TTE where an electro-optic conversion and an electrical generation are performed between a line optical channel (LOC) and an electrical channel.

2043 submarine digital line section (SDLS): A bidirectional continuous optical path along which one line optical channel (LOC) links two terminal transmission equipments (TTEs) at the SEOI level.

2044 terrestrial interface (TI): The interface between the submarine system and the terrestrial network.

2045 intermediate terrestrial interface (ITI): It is to be noted that the terminal transmission equipment (TTE) can be composed of two distinct pieces of equipment interfaced together, the first piece, called submarine cable transmission terminal equipment (SCTTE), facing with submarine cable, and the second piece, called terrestrial network transmission terminal equipment (TNTTE), facing the terrestrial network. In this case, an intermediate interface is required, which links the two pieces of equipment. This interface is composed of bidirectional data interfaces and, where applicable, an extra link used to exchange information between the two pieces of TTE equipment.

2046 dispersion map: For further study.

2047 polarization hole burning: For further study.

2048 Q-time variations margin (or time varying system penalty (TVSP)): A margin that defines an impairment due to performance fluctuations around the mean performance. Five standard deviations of Q factor should be allocated.

2049 generalized optical signal to noise ratio (GOSNR): Optical signal to noise ratio including the total noise contributions due to linear noise and fibre nonlinearities, while referenced in the noise bandwidth typically of 12.5 GHz or 0.1 nm at wavelength of 1550 nm.

2050 generalized signal to noise ratio (GSNR): Signal to noise ratio including the total noise contributions due to linear noise and fibre nonlinearities, while referenced in the same signal and noise bandwidth.

2051 signal to noise ratio (SNR): Power ratio between signal and noise components.

2052 interoperable cable portion interface: The interface before and after the optical coupling junction (OCJ) in an interoperable cable system.

2053 guided acousto-optic wave Brillouin scattering (GAWBS): An acousto-optic effect whereby light propagating along an optical fibre can be scattered in the forward direction by interacting with thermally excited transverse acoustic modes of the fibre. The locally induced phase and polarization modulations translate into a crosstalk noise, the variance of which is proportional to distance and signal power.

2054 guided acousto-optic wave Brillouin scattering signal-to-noise ratio (SNR_{GAWBS}): The guided acousto-optic wave Brillouin scattering signal-to-noise ratio (SNR_{GAWBS}) is the contribution from the acoustic modes of the transmission fibre scattering light in the forward direction with a frequency shift that is determined by the acoustic mode oscillation frequency.

2055 generalized droop: The generalized droop model aims to account for the aggregation of multiple sources of Gaussian noise (or signal distortions modelled as a Gaussian noise) under the constraint of fixed total power.

3.3 Terms relevant to terminal equipment

3001 service channel: A communication channel established between associated terminal stations through the optical fibre submarine cable system for the purpose of operating and maintaining the system.

3002 order wire channel: A voice service channel.

3003 PFE earth protection equipment: A protective device that automatically routes the power-feeding current to the station earth under abnormal power feeding equipment (PFE) earth conditions.

3004 PFE personnel protection equipment: Protective equipment installed to prevent personnel from gaining access to dangerous potentials.

3005 PFE mutual protection: The ability of a power feeding unit installed at one end of a link to provide in an emergency situation the whole of the power necessary for a given link, when in normal operating condition that total power is shared between the power feeding equipment installed at both ends of the link.

3006 PFE nominal current: The nominal value of the power feeding current.

3007 maximum PFE current: The value of the power feeding current above which the power feeding equipment (PFE) switches off in order to protect the system.

3008 maximum PFE voltage: The value of the voltage at the power feeding equipment (PFE) output above which the PFE switches off in order to protect the system.

3009 PFE current stability: The limitation of the variation of the power feeding equipment (PFE) current in time.

3010 FEC encoder: A unit included in the transmit terminal transmission equipment (TTE) which accomplishes all the digital operations needed to translate the digital data at system interface (A) into the desired coded bit sequence according to the employed forward error correction (FEC) algorithm.

3011 FEC decoder: A unit included in the receive terminal transmission equipment (TTE) which accomplishes the correction of the data transmitted through the submarine portion into symbol decisions that reproduce, as accurately as possible, the data that was encoded by the forward error correction (FEC) encoder.

3012 wavelength multiplexer (WM): The equipment required to combine several line optical channels (LOCs) and/or WDM coming from different fibres into a common WDM composed of all the combined LOCs.

3013 wavelength demultiplexer (WD): The equipment required to split a WDM into several LOCs and/or WDM to be carried on different fibres.

3014 submarine cable transmission terminal equipment (SCTTE): For further study.

3015 terrestrial network transmission terminal equipment (TNTTE): For further study.

3016 umbilical: The extra link used at an intermediate terrestrial interface (ITI) to exchange information between the two pieces of terminal transmission equipment (TTE) which are the submarine cable transmission terminal equipment (SCTTE) and the terrestrial network transmission terminal equipment (TNTTE).

3017 outer code: For further study.

3018 inner code: For further study.

3019 hard decision decoding: Hard decision decoding refers to the use of a single quantization level in bit sampling, resulting in binary bit information provided to the decoding process.

3020 soft decision decoding: For the same received waveform, soft decision decoders make use of multiple levels of quantization (typically three or more).

3021 coding gain: Coding gain means the improvement of received optical sensitivity by forward error correction (FEC), without considering the penalty caused by the bit rate increasing.

3022 net coding gain: Net coding gain means the improvement of received optical sensitivity by forward error correction (FEC), considering the penalty caused by the bit rate increasing.

3023 Q limit: Q limit means the minimum required allowable Q factor of the input signal for the receiver decision circuit in order to achieve a reference BER.

3024 redundancy ratio: Redundancy ratio describes the ratio between the number of information bits covered by the forward error correction (FEC) and the number of bits after encoding comprising the same information plus the added redundancy information.

3025 latency: Latency means transmission delay for forward error correction (FEC) encoding, decoding, interleaving and de-interleaving.

3.4 Terms relevant to optical submarine repeaters and branching units

4001 repeater (or BU) housing: The mechanical part of a repeater (or branching unit).

4002 repeater (or BU) optoelectronic unit: The optoelectronic part of a repeater (or branching unit).

4003 repeater (or BU) supervisory circuit: Electronic circuits installed in a repeater (or branching unit) to perform, in association with the supervisory equipment installed in the terminal station, system supervision and fault localization.

4004 repeater (or BU) power supply and protection circuit: The electronic circuits installed in a repeater (or BU) to power, in association with the power feeding equipment (PFE), the repeater (or BU) electronic unit with a regulated voltage, and to provide a protection against electrical discharges due to cable discharge or lightning.

4005 branching unit sea electrode: An electrode provided at a branching unit (BU) to establish the return path of the power feeding current through the sea.

4006 full fibre drop BU (FFD-BU): A BU where the optical interconnection between the three submarine cables is made by physically connecting fibre pairs between any two cables.

4007 wavelength division multiplexing branching unit (WDM-BU): A branching unit (BU) where the optical interconnection between the three submarine cables is made through WM and

WD, which is adding and dropping one or more line optical channels (LOCs) out of the N-wavelength division multiplex (N-WDM).

4008 fixed optical add/drop multiplexing-branching unit (FOADM-BU): A branching unit (BU) with OADM function where the added, dropped and passed-through wavelengths are fixed.

4009 reconfigurable optical add/drop multiplexing-branching unit (ROADM-BU): A branching unit (BU) with OADM function where the added, dropped and passed-through wavelengths can be dynamically modified.

3.5 Terms relevant to optical fibre submarine cable

5001 lightweight cable: Cable suitable for laying, recovery and operation where no special protection is required.

5002 lightweight protected cable: Lightweight cable with an additional protective layer.

NOTE – This cable is suitable for laying, recovery and operation in areas where cable erosion or fish-bite risk is significant.

5003 single armoured cable: A cable with a single layer of protective armour.

NOTE – This cable is suitable for laying, burial, recovery and operation, and is suitably protected for specific areas in shallow water.

5004 double armoured cable: A cable with a double layer of protective armour.

NOTE – This cable is suitable for laying, burial, recovery and operation, and is suitably protected for specific areas in shallow water.

5005 rock armoured cable: A cable with a multiple layer of protective armour (usually two), the outer layer being wound with a small pitch.

NOTE – This cable is suitable for laying, recovery and operation, and is suitably protected for specific areas in shallow water.

5006 land cable: Cable with suitable protection for installation in ducts or direct burying in the ground.

5007 cable breaking load (CBL): The minimum guaranteed breaking strength of the cable, with ends fixed, taking into account material and dimensional tolerances of the cable components.

5008 fibre-breaking cable load: The load which, when applied longitudinally to the cable with fixed ends, results in an instantaneous fibre break.

5009 nominal permanent tensile strength (NPTS): The maximum permanent cable tension that does not significantly reduce the system performance, lifetime and reliability. NPTS represents the maximum residual tension that may be permanently applied to the cable on the seabed after installation.

NOTE – NPTS is also known elsewhere as the maximum permanent cable load.

5010 nominal operating tensile strength (NOTS): The maximum average operational tension which the cable can support for the period required for marine operations (typically 48 hours) without significantly reducing the system performance, lifetime and reliability. NOTS represents the maximum average operational tension during installation or repair.

NOTE – NOTS is also known elsewhere as the operational cable load.

5011 nominal transient tensile strength (NTTS): The maximum short-term tension that can be applied to the cable during an at-sea recovery operation over a cumulative period of approximately one hour without significantly reducing the system performance, lifetime and reliability. NTTS represents the maximum transient or unexpected tension that may be applied to the cable and is normally limited to a percentage of the cable breaking load (CBL) from a mechanical safety point of view.

NOTE – NTTS is also known elsewhere as the transitory cable load.

5012 longitudinal water propagation: The cable length being penetrated by water as a function of water depth or pressure and of duration of submission for an open-ended cable.

5013 cable jointing box: A mechanical assembly used to join two optical fibre submarine cables.

5014 cable coupler (or cable termination): A mechanical assembly used to join an optical fibre submarine cable to a repeater or a branching unit.

5015 cable transition: A transition between different types of cables, which can be achieved using either a transition cable or a transition joint.

5016 cable gyration: The rotation of one end of a cable length relative to the other end.

5017 cable elongation with fixed end: The cable elongation under a load, when both ends are prevented from rotating.

5018 cable elongation with free gyration: The cable elongation under a load, when one end is free to rotate.

5019 cable modulus: The length of cable, measured in km, the weight of which in water is equal to the cable breaking load.

5020 cable operational modulus: The length of cable, measured in km, the weight of which in water is equal to the nominal operation tensile strength (NOTS).

5021 cable full safe modulus: The length of cable, measured in km, the weight of which in water is equal to the nominal permanent tensile strength (NPTS).

5022 cable transitory modulus: The length of cable, measured in km, the weight of which in water is equal to the nominal transient tensile strength (NTTS).

5023 cabled fibre attenuation: The optical attenuation of the cable, including any fibre overlength and fibre splices present, as measured in dB per length of cable.

5024 cabled fibre strain: The strain in an optical fibre in a cable after manufacture.

5025 cable safety margin: The cable safety margin is the difference in tensile load between the measured load at failure and the maximum installation/recovery load proposed by the installer. The cable safety margin may typically be expressed as a percentage of measured load at failure.

5026 duct shielded cable: A cable with a circumferential safety shield which may be the fish-bite protection shield, and which is suitable to be pulled into ducts.

5027 tight cable structure: A cable structure where the fibres are strongly maintained in the cable, so that the fibre elongation is essentially equal to that of the cable.

5028 loose cable structure: A cable structure where the fibres are free to move inside the cable, so that the fibre elongation is lower than that of the cable, staying at zero until the cable elongation reaches a given value.

5029 transitory cable load: The load that could be accidentally encountered, particularly during recovery operations.

5030 operational cable load: The load that could be encountered during repairs.

5031 permanent cable load: The load that characterizes the status of cable after lay.

5032 minimum cable bending radius: The bending radius which is a guideline for cable handling.

3.6 Terms relevant to manufacturing and installation

6001 qualification: The activity, part of the development process, intended to demonstrate that a technology, a component or an assembly is able to comply with its performance and reliability specification.

6002 sea trial: A test made at sea during the development process, as part of the qualification of the submarine portion.

6003 certification: The activity, part of the manufacturing process, intended to eliminate all components or subassemblies which present a risk of not complying with their performance and reliability specification.

6004 batch qualification: The activity, part of the manufacturing process, intended to eliminate batches of components suspected to present a generalized failure mechanism.

6005 route survey: The activity performed prior to cable laying so as to select the cable route and cable protection (fish-bite protection, armour, burying).

6006 link assembly: The activity of jointing the cable sections, repeaters and branching units, together with monitoring the performance of each cable section.

6007 ship loading: The operation of installing the submarine portion, or fractions of it, on board the cable ship prior to laying.

6008 cable laying: The operation of laying on the sea bottom the submarine portion or fractions of it.

6009 laying limit condition: Weather and sea conditions above which laying should not be undertaken or should be interrupted.

6010 slack control: Operation consisting of controlling that a predetermined cable overlength (slack) is laid.

6011 shore end: The end of the submarine cable to be laid from the cableship toward the beach so as to be connected to the land cable.

6012 initial splice: The splice made on board the cableship between parts of the submarine portion at the beginning of a lay.

6013 final splice: The splice made on board the cableship between parts of the submarine portion at the end of a lay.

6014 cable burial: The operation consisting of burying the cable in the seabed so as to provide better cable protection.

NOTE – The burial operation may be carried out either during installation or as a post-lay activity.

6015 laying angle: The angle between the cable being laid (which is theoretically along a straight line) and the sea surface.

6016 manufacturing inspection: The activity during the manufacturing process intended to verify that the quality plan is respected, that each operation is accomplished along the agreed procedure, and that the result is satisfactory.

6017 commissioning testing: A test 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 network management are operating.

3.7 Terms relevant to the maintenance of the submarine portion

7001 cable recovery: The operation of recovering a cable from the sea bottom.

7002 deep sea repair: The operation of repairing a submarine cable system installed in deep sea.

7003 shallow water repair: The operation of repairing a submarine cable system installed in shallow water.

7004 mini system: A length of cable, pre-equipped with repeaters, to be used for replacing one or more optical cable sections and the associated repeaters during a sea repair.

7005 spare repeater (or BU): An additional repeater (or BU) stored in a marine depot or on board a cableship to be used during a repair operation.

7006 spare cable: An additional cable length, stored in a marine depot or on board a cableship to be used during a repair operation.

7007 spare storage condition: The environment condition for storing the spare repeaters and cable.

7008 repair safety procedure: Procedures to be applied on board the cableship and in the terminal station so as to ensure the safety of personnel during a repair.

7009 submersible robot: A remote-controlled submersible vehicle which can be used for locating, observing, post-lay burying or recovering a cable installed in shallow water.

7010 routine maintenance: The periodic monitoring of the system parameters and preventive redundancy switching performed from the terminal station using the supervisory system.

7011 fault localization: For further study.

7012 fault location: For further study.

7013 optical time domain reflectometry (OTDR): The optoelectronic instrument used to characterize the optical fibres. OTDR injects a series of optical pulses into the fibre under test. It also extracts, from the same end of the fibre, light that is scattered and reflected back from points in the fibre where the index of refraction changes. The strength of the return pulses is measured and integrated as a function of time, and is plotted as a function of fibre length.

7014 coherent optical time domain reflectometry (COTDR): COTDR has similar features to OTDR, but uses coherent detection instead of direct detection, which gives it higher sensitivity and higher frequency selectivity than OTDR.

7015 monitoring equipment (ME): Equipment used to monitor the status of the submerged plant of a submarine cable system, which is classified into two categories according to the monitoring mechanism: passive monitoring equipment, or active monitoring equipment.

NOTE – For monitoring systems for optical fibre submarine cable systems, please refer to [ITU-T G.979].

7016 active monitoring equipment (AME): One of the two categories of MEs which monitors the status of submerged equipment by communicating with the monitored equipment to obtain a performance status.

7017 passive monitoring equipment (PME): One of the two categories of MEs which does not communicate with the submerged plant, but monitors the status of the submerged plant by detecting optical/electrical paths, e.g., monitoring equipment based on OTDR/COTDR. To get a performance status, return paths within submerged plant (described in clause 8.5 of [ITU-T G.977]) are necessary.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AME	Active Monitoring Equipment
BU	optical submarine Branching Unit
CBL	Cable Breaking Load

COTDR	Coherent Optical Time Domain Reflectometry
CSF	Cut-off Shifted single-mode Fibre
CTE	Cable Terminating Equipment
DCF	Dispersion Compensating single-mode Fibre
DRA	Distributed Raman Amplifier
DSF	Dispersion Shifted single-mode Fibre
DWDM	Dense Wavelength Division Multiplexing
DWDMS	Dense Wavelength Division Multiplexing System
ECR	Electrical Command Response
FEC	Forward Error Correction
FFD-BU	Full Fibre Drop Branching Unit
FOADM-BU	Fixed Optical Add/Drop Multiplexing-Branching Unit
GAWBS	Guided Acousto-optic Wave Brillouin Scattering
GOSNR	Generalized Optical Signal to Noise Ratio
GSNR	Generalized Signal to Noise Ratio
ITI	Intermediate Terrestrial Interface
LEF	Large Effective area single-mode Fibre
LOC	Line Optical Channel
ME	Monitoring Equipment
MTC	Marinized Terrestrial Cable
N-WDM	N-Wavelength Division Multiplex
NDF	Negative Dispersion single-mode Fibre
NOTS	Nominal Operating Tensile Strength
NPTS	Nominal Permanent Tensile Strength
NTTS	Nominal Transient Tensile Strength
NZDSF	Non-Zero Dispersion Shifted single-mode Fibre
OCJ	Optical Coupling Junction
OFA	Optical Fibre Amplifier
OSE	Optical Submarine Equalizer
OTDR	Optical Time Domain Reflectometry
OTH	Optical Transport Hierarchy
OTN	Optical Transport Network
PDF	Positive Dispersion single-mode Fibre
PFE	Power Feeding Equipment
PHB	Polarization Hole Burning
PME	Passive Monitoring Equipment
ROADM-BU	Reconfigurable Optical Add/Drop Multiplexing-Branching Unit

ROPA	Remote Optically Pumped Amplifier
SCOI	Submarine Cable Optical Interface
SCS	Single Channel System
SCTTE	Submarine Cable Transmission Terminal Equipment
SDLS	Submarine Digital Line Section
SEOI	Submarine Electro-Optic Interface
SMF	Single-Mode Fibre
SNR	Signal to Noise Ratio
STE	System Terminal Equipment
SWS	Single Wavelength System
TI	Terrestrial Interface
TNTTE	Terrestrial Network Transmission Terminal Equipment
TSE	Terminal Station Equipment
TTE	Terminal Transmission Equipment
TVSP	Time Varying System Penalty
UBM	Undersea Branching Multiplexer
WD	Wavelength Demultiplexer
WDM	Wavelength Division Multiplexing
WDM-BU	Wavelength Division Multiplex-Branching Unit
WDMS	Wavelength Division Multiplexing System
WDM-TTE	Wavelength Division Multiplex-Terminal Transmission Equipment
WM	Wavelength Multiplexer
WNZDF	Wideband Non-Zero Dispersion single-mode Fibre

5 Conventions

In this Recommendation each definition is preceded by a number, see example below:

1008 terminal station equipment (TSE): The TSE comprises the STE and the ancillary equipment used for the operation of the optical fibre submarine cable system.

The number indicates the order of the definitions in each subclause. In this example, 1008 indicates that terminal station equipment (TSE) is the 8th definition in subclause 3.1.

Appendix I

Alphabetical list of terms defined in this Recommendation

(This appendix does not form an integral part of this Recommendation.)

7015 active monitoring equipment (AME)
2018 apparent line error ratio
2032 availability
6004 batch qualification
1006 beach joint
1021 bipolar repeater
1022 branching unit (BU)
4005 branching unit sea electrode
5007 cable breaking load (CBL)
6014 cable burial
5014 cable coupler (or cable termination)
5017 cable elongation with fixed end
5018 cable elongation with free gyration
5021 cable full safe modulus
5016 cable gyration
5013 cable jointing box
6008 cable laying
5019 cable modulus
5020 cable operational modulus
7001 cable recovery
5025 cable safety margin
2024 cable section margin
1014 cable terminating equipment (CTE)
5015 cable transition
5022 cable transitory modulus
5023 cabled fibre attenuation
5024 cabled fibre strain
6003 certification
3021 coding gain
7014 coherent optical time domain reflectometry (COTDR)

6017 commissioning testing
1047 cut-off shifted single-mode fibre (CSF)
7002 deep sea repair
1027 deep water
1035 dense wavelength division multiplexing (DWDM)
1036 dense wavelength division multiplexing system (DWDMS)
2003 digital line section
1048 dispersion compensating single-mode fibre (DCF)
2046 dispersion map
1049 dispersion shifted single-mode fibre (DSF)
1042 distributed Raman amplifier (DRA)
5004 double armoured cable
5026 duct shielded cable
1061 electrical command response (ECR)
2019 electroding
1044 elementary cable
1028 elementary cable section
2033 end-to-end performance monitoring
2025 equipment margin
2030 expected ship repair number
7011 fault localization
7012 fault location
3011 FEC decoder
3010 FEC encoder
2036 FEC frame
5008 fibre-breaking cable load
6013 final splice
4008 fixed optical add/drop multiplexing-branching unit (FOADM-BU)
2035 forward error correction (FEC)
4006 full fibre drop BU (FFD-BU)
1037 gain equalizer
2055 generalized droop
2049 generalized optical signal to noise ratio (GOSNR)
2050 generalized signal to noise ratio (GSNR)
2028 guaranteed margin
2053 guided acousto-optic wave Brillouin scattering (GAWBS)
2054 guided acousto-optic wave Brillouin scattering signal-to-noise ratio

3019 hard decision decoding
1046 hybrid-fibre type elementary cable
6012 initial splice
3018 inner code
1025 integration line optical interface
1024 integration specification
2045 intermediate terrestrial interface (ITI)
1065 interoperable cable portion
2052 interoperable cable portion interface
5006 land cable
1004 land portion
1066 land repeater
1050 large effective area single-mode fibre (LEF)
3025 latency
6015 laying angle
6009 laying limit condition
5001 lightweight cable
5002 lightweight protected cable
2021 line bit rate
2022 line code
2017 line error ratio
2015 line frame
2038 line optical channel (LOC)
6006 link assembly
2040 LOC-TTE
1059 longitudinal compatibility
5012 longitudinal water propagation
5028 loose cable structure
1012 maintenance controller
6016 manufacturing inspection
1031 marinized terrestrial cable (MTC)
3007 maximum PFE current
3008 maximum PFE voltage
7016 monitoring equipment (ME)
7004 mini system
5032 minimum cable bending radius

1051 negative dispersion single-mode fibre (NDF)
3022 net coding gain
5010 nominal operating tensile strength (NOTS)
5009 nominal permanent tensile strength (NPTS)
5011 nominal transient tensile strength (NTTS)
1054 non-dispersion shifted single-mode fibre (SMF)
1052 non-zero dispersion shifted single-mode fibre (NZDSF)
5030 operational cable load
1062 optical coupling junction
2006 optical detector input
1018 optical fibre land cable
1017 optical fibre station cable
1019 optical fibre submarine cable
1002 optical fibre submarine cable link
1003 optical fibre submarine cable network
1001 optical fibre submarine cable system
2009 optical interface
2014 optical line signal
2002 optical power budget
2004 optical section
2005 optical source output
1058 optical submarine equalizer (OSE)
1020 optical submarine repeater
7013 optical time domain reflectometry (OTDR)
1057 optical transport hierarchy (OTH)
1056 optical transport network (OTN)
3002 order wire channel
3017 outer code
2029 overload margin
7017 passive monitoring equipment (PME)
5031 permanent cable load
3009 PFE current stability
3003 PFE earth protection equipment
3005 PFE mutual protection
3006 PFE nominal current
3004 PFE personnel protection equipment
2047 polarization hole burning

1053 positive dispersion single-mode fibre (PDF)
1015 power feed earth
1016 power feed earth electrode cable
2020 power feeding current
1013 power feeding equipment (PFE)
2037 Q factor
3023 Q limit
2048 Q-time variations margin
6001 qualification
1043 Raman gain coefficient
2011 receive terminal optical interface
4009 reconfigurable optical add/drop multiplexing-branching unit (ROADM-BU)
3024 redundancy ratio
2031 reliability budget
1041 remote optically pumped amplifier (ROPA)
2026 repair allowance
7008 repair safety procedure
4001 repeater (or BU) housing
2013 repeater (or BU) optical input interface
2012 repeater (or BU) optical output interface
4002 repeater (or BU) optoelectronic unit
4004 repeater (or BU) power supply and protection circuit
4003 repeater (or BU) supervisory circuit
1029 repeatered submarine cable
1030 repeaterless submarine cable
5005 rock armoured cable
6005 route survey
7010 routine maintenance
6002 sea trial
3001 service channel
1026 shallow water
7003 shallow water repair
6007 ship loading
6011 shore end
1040 shunt fault
5003 single armoured cable
1032 single wavelengthsystem (SWS)

1045 single-fibre type elementary cable
2051 signal to noise ratio (SNR)
6010 slack control
1039 slope equalizer
3020 soft decision decoding
7006 spare cable
7005 spare repeater (or BU)
7007 spare storage condition
2039 submarine cable optical interface (SCOI)
3014 submarine cable transmission terminal equipment (SCTTE)
2043 submarine digital line section (SDLS)
2042 submarine electro-optic interface (SEOI)
1005 submarine portion
7009 submersible robot
2034 supervisory of an optical fibre submarine cable system
2007 supervisory section
1011 supervisory system
2001 system design life
2008 system interface
2016 system interface bit rate
2023 system performance penalty
1009 system terminal equipment (STE)
1064 terminal portion
1007 terminal station
1008 terminal station equipment (TSE)
1010 terminal transmission equipment (TTE)
2044 terrestrial interface (TI)
3015 terrestrial network transmission terminal equipment (TNTTE)
5027 tight cable structure
1038 tilt equalizer
2048 time varying system penalty (TVSP)
5029 transitory cable load
2010 transmit terminal optical interface
1060 transverse compatibility
3016 umbilical
2027 unassigned margin
1023 undersea branching multiplexer (UBM)

3013 wavelength demultiplexer (WD)

1033 wavelength division multiplexing (WDM)

1034 wavelength division multiplexing system (WDMS)

3012 wavelength multiplexer (WM)

4007 WDM-BU

2041 WDM-TTE

1055 wideband non-zero dispersion single-mode fibre (WNZDF)

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