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| Issue:           | 1.0               |
| Date:            | 04 June 2011      |
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## Level 2

### Optical Fibre Network Design

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## Issue record

| Issue | Date      | Comments                                             |
|-------|-----------|------------------------------------------------------|
| 1.0   | June 2011 | New standard containing content from SP/FTN(D&D)/008 |

## Compliance

This Network Rail standard is mandatory and shall be complied with by Network Rail and its contractors if applicable from 03 September 2011.

When this standard is implemented, it is permissible for all projects that have formally completed GRIP Stage 3 (Option Selection) to continue to comply with the issue of any relevant Network Rail standards current when GRIP Stage 3 was completed and not to comply with requirements contained herein, unless stipulated otherwise in the scope of this standard.

## Reference documentation

|                 |                                                             |
|-----------------|-------------------------------------------------------------|
| BS EN 60529     | Degrees of Protection Provided by Enclosures (IP Code)      |
| ETS 300 019-1-3 | Environmental Conditions for Telecommunications Equipment   |
| NR/L2/TEL/00014 | Optical Fibre Telecommunications Cables                     |
| NR/GN/TEL/30138 | Buried Cable Route and Cable Route Through Station Platform |
| NR/GN/TEL/30139 | The Survey and Design of Telecoms Cable and Route           |
| NR/GN/TEL/30140 | Cable Route Installation                                    |
| NR/L2/TEL/30161 | Optical Patchcords and Pigtales                             |
| NR/L2/TEL/30162 | Jointing, Terminating, and Testing Optical Fibre Cables     |
| RT/E/C/11821    | Siting Requirements for Lineside Apparatus Housings         |

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## 1 Purpose

The purpose of this standard is to set out the principles and considerations to be taken into account for additions to, or modifications of, Network Rail's optical fibre infrastructure with the objectives of maximise its potential capacity and applying a consistent approach that will perpetuate reliability, availability and maintainability

## 2 Scope

This Network Rail standard sets out the parameters to promote consistent optical fibre cabling infrastructure throughout Network Rail's optical fibre network and specifies permissible optical loss and configuration of the network that will extend and preserve the networks reliability, availability and maintainability.

The design principles and parameters set out in this standard apply to all designs that grow, change, or repair Network Rail's optical fibre infrastructure, including optical fibre infrastructure supporting Signalling circuits and Electrical Plant applications but excluding intra-building optical fibre infrastructure with no operational traffic.

## 3 Abbreviations

|        |                                                                          |
|--------|--------------------------------------------------------------------------|
| ADM    | Add-Drop Multiplexor                                                     |
| BTS    | Base Transceiver Station for propagation of GSM-R coverage               |
| CCTV   | Closed circuit television                                                |
| DBS    | Directly buried sub-duct                                                 |
| DI-SAC | Double insulated super armoured optical fibre cable                      |
| DSL    | (high bit-rate) Digital Subscribers Line                                 |
| ETSI   | European Telecommunications Standards Institute                          |
| EVA    | Ethylene vinyl acetate                                                   |
| FTN    | Network Rail's Fixed Telecom Network                                     |
| GSM-R  | Global System for Mobiles, for Railways                                  |
| HDPE   | High density polyethylene                                                |
| MBD    | Minimum bending diameter                                                 |
| MBR    | Minimum bending radius                                                   |
| MDPE   | Medium density polyethylene                                              |
| MSC    | Mobile Switching Centre (for GSM-R)                                      |
| PBT    | Polybutylene Teraphthalate                                               |
| PMux   | Primary Multiplexor                                                      |
| PDR    | Property development rights                                              |
| PE     | Polyethylene (aka polythene)                                             |
| PTO    | Public Telecommunications Operator                                       |
| OTDR   | Optical Time Domain Reflectometer                                        |
| REB    | Relocatable Equipment Building                                           |
| STM -1 | Synchronous Transfer Module One; SDH term for transmission at 155 Mbit/s |

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|         |                                                                              |
|---------|------------------------------------------------------------------------------|
| STM -16 | Synchronous Transfer Module Sixteen; SDH term for transmission at 2.5 Gbit/s |
| UfmX    | Under Farm Crossing                                                          |
| UftX    | Under Foot Crossing                                                          |
| UrdX    | Under Road Crossing                                                          |
| UTX     | Under Track Crossing                                                         |
| WDM     | Wave division multiplexing                                                   |
| ZHLS    | Zero halogen, low smoke                                                      |

## 4 Definitions

### Access Node

A generic term for a transmission node site containing one or more STM-1 ADMs and PMux, typically accommodated in an active trackside cabinet or relocatable building at a GSM-R site. Refer also to Access Node SR and Access Node DR below

### Access Node, SR

A Type 16 Access Node with a single cable route to it, containing one or two ADMs, but with low resilience requirements

### Access Node, DR

Type 13, 14 or 15 Access Nodes with multiple, diverse cable routes to it, containing one or two ADMs and provision for signal resynchronising but with higher resilience requirements

### Access ring

A SDH ring carrying access traffic

### Access traffic

Transmission at STM-1 level

### Active Transmission Equipment Housing

A lineside cabinet with climate control to accommodate active transmission equipment.

### Cable manifold

A device used to terminate an optical fibre cable's sheaths and CSM but permit the tubes bearing the optical fibres to continue in protective, kink-proof, transport tubing to the termination trays.

### Centre-to-centre

Method of measurement of the length between adjacent joint locations

### Core Node

A transmission node site containing one or more STM-16 ADMs, typically accommodated in an REB or building

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### **Core ring**

A SDH ring carrying core traffic

### **Core traffic**

Transmission at STM-16 level or higher

### **DI-SAC**

A heavily armoured optical fibre cable designed for long term deployment on the ground surface without supplementary protection.

### **Fibre section**

Optical fibre between two adjacent Core Nodes

### **Fibre sub-section**

Optical fibre between two adjacent Access Nodes or between an Access Node and a Core Node

### **FIST GCO2**

A make of water-tight optical fibre joint closure designed to be accommodated at trackside.

### **Green Zone**

A site sufficiently far away from the nearest track that, at its normal maximum line speed, there is no requirement to interfere with the operational railway or erect a fence in order to create a green zone as defined in GO/RT3002.

### **Occupation Crossing**

A type of Farm Crossing

### **Parallelism**

The presence of National Grid HV lines running parallel with the railway for more than 1 km

### **Spliceless joint**

An optical fibre joint position where none, or not all, of the fibres are severed. Typically used for spurring out fibres while leaving straight through fibres intact. Where a spliceless joint is left for spurring in the future, for example for a subsequent spur cable, a suitable loop of cable is left uncut in a FIST GCO2 in a joint bay.

### **Tunnel repeater**

A device designed to extend GSM-R coverage through tunnels.

### **Touch potential**

The permissible limits of voltage between two bodies as defined in BS EN 50122 and ITU-T K33, beyond which a potential risk to health for humans and animals is posed. The limits are 842V for 100 mS, 670V for 200ms, 65V for 300s and 60V indefinitely

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## 5 Network Rail's Optical Fibre Architecture

### 5.1 General Principles

The majority of Network Rail's optical fibre infrastructure is delivered through the FTN (Fixed Telecoms Network) although there are separate networks that deliver functionality for signalling and electrical applications. These separate networks may interface with the FTN so they shall be designed to the same principles as the FTN.

Network Rail's FTN is primarily based on SDH transmission over optical fibre cables using ring topology, and employs discrete transmission nodes connected by optical fibre and copper cables. This design provides a high degree of resilience by ensuring that all critical elements can be dual fed to prevent vulnerability to common mode failures.

Transmission nodes are divided into discrete types based of their functionality. Types 1 to 12 are termed "Core Nodes" and deliver core connectivity while Types 13 to 16 are termed "Access Nodes" and provide managed connection to and delivery of services over the core network.

In order to promote the intrinsic resilience, manageability and maintainability of ring topology certain tubes in the optical fibre cables are reserved to support systems with particular applications and these pre-allocations are set out in Section 11.

For optical fibre cables constructed with 4 fibres per tube, each pair of fibres that is supporting core traffic shall have its own dedicated tube to minimise the risk of disturbance of core traffic, ie 2 core rings shall not share the same tube.

Additionally, where a cable is supporting core traffic in multiple core rings, one separate tube shall be dedicated to each ring. Two spare fibres in a 4-fibre tube that are dedicated for core traffic are reserved for maintenance purposes.

A tube that is supporting access traffic shall be dedicated to access traffic, but the second pair of fibres in the tube may support a second access ring.

### 5.2 Core Nodes

Core Nodes will provide the key points of the network by interfacing with multiple transmission rings, and providing self-healing transmission systems.

### 5.3 Access Nodes

Access Nodes will provide interfaces with the railway infrastructure by assembling data from railway operational circuits and other services into packages for transmission over the FTN.

For the purposes of this document, all Access Nodes are divided into two types to reflect their required level of physical resilience:

**An Access Node, SR** is fed by a single cable route and will contain a single ADM and are the most numerous. Refer to the drawings in the appendices for clarity. (For information and reference to transmission documentation, these Access Nodes will consist of Type 16 nodes.)

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**An Access Node, DR** supports systems that would be severely impaired by loss of optical connectivity and are therefore fed by two or more, physically diverse cable routes. They contain multiple ADMs on one or more transmission rings. Refer to the drawings in the appendices for clarity. (For information and reference to transmission documentation, these Access Nodes will consist of Type 13, 14 or 15 nodes.)

## 6 Surveying requirements

The first activity in producing a robust fibre optic cable network design is to undertake a comprehensive survey to determine how new elements will interface with existing elements and topographical features. A cable route survey is where design of the cable route takes place and to a greater or lesser extent it will affect the application of the design of the optical fibre network. Accordingly a fibre cable network survey should be combined with the cable route survey to correlate requirements and elements.

The requirements for cable route surveys are set out in NR/GN/TEL/30139, and for the purposes of the optical fibre cable network survey the following shall be considered and recorded where pertinent:

- Centre to centre optical cable length.
- The proposed locations for joints
- The requirement for an additional joint at UTXs, URXs, UFMXs, UftXs, and platform duct routes to facilitate cable pulling.
- The proposed positions of sheath gaps
- The proposed positions of spur cables
- The proposed positions of terminations
- Route separation at Access nodes, DR and Core Nodes
- Entries to buildings

In the event of contradiction the requirements set out in this document shall take precedence.

NOTE: The resilience requirements of section 10 of this document are crucial

### 6.1 Centre to centre cable lengths

The distance between optical cable joints shall be maximised in order to minimise the number of joints and therefore minimise the optical loss due to splicing. Refer to section 6.2 below for joint spacing tolerance.

The cable length to be supplied between adjacent joints shall be measured and recorded on a centre-to-centre basis to minimise the associated cost of surplus ordered cable. The actual length between joints shall be recorded during the survey, but the following Allowances shall be added to the measured lengths in the order and in the Bill of Quantities:

#### Allowances

- 1% of the measured length for cable deviation within the route
- 5 metres for each cable end to be jointed
- 10 metres for each cable end to be terminated, except at large buildings

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where additional length may be required to reach the termination location.

Except for a spur cable to an Access Node, a cable shall only terminate in a transmission node and not in a joint. A joint shall not be designed as a distribution point for main cables. For example, at a junction the cables from the branches of the junction shall extend to the nearest appropriate node and terminate there, and a joint shall not be sited at the Access Node for the purpose of distributing fibres along the branches.

## 6.2 Joint Locations

Where practicable, optical fibre cable joints shall be spaced  $2,000 \pm 10\%$  metres apart to facilitate manual handling of cable drums, and the number of joints shall be minimised to avoid unnecessarily increasing optical attenuation. Local topographical features will determine the location of joint bays and joints shall be placed to minimise the requirement for civil works whilst optimising the use of natural permanent green zones but in any event joints shall be spaced further than 250 metres apart so that consecutive events on OTDR traces can be discriminated.

Each joint shall be positioned in a permanent green zone to promote safe working and facilitate maintenance activity. Optical fibre joints need to allow for re-entry so it is essential that where practicable they can be moved to and entered in permanent green zones even if the joint bay itself is not located in a permanent green zone. Where space is limited then insulated handrails may be required in accordance with RT/E/C/11821 to create a permanent green zone for the optical fibre joint and jointers tent.

Each joint shall be sited at trackside in a joint bay or an approved chamber.

## 6.3 Sheath Gaps

The metallic sheath of fibre cables shall be gapped at strategic points to keep continuous lengths short to prevent the build up of hazardous voltages caused by electric currents from traction electrification or the National Grid. Refer to NR/L2/TEL/30162 for details of how and where sheaths should be gapped.

## 6.4 Core Node Sites

Core nodes are generally accommodated in existing lineside buildings or REBs and connected to the network with physically diverse cables. The design shall ensure that the resilience requirements of Section 10 are met in full. Refer to the diagrams in the appendices.

## 6.5 Access Node Sites

Access Nodes, SR will typically be accommodated in active trackside equipment housings or a relocatable building and shall be connected to the network with a single spur cable, which shall run from a joint bay in the existing route to the site of the proposed Access Node. Refer to the diagrams in the appendices.