Telecommunications Authority of Trinidad and Tobago

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on

Technical Standards for Public Fixed Telecommunications Networks

(First round)

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List of Abbreviations

ASTM	American Society for Testing and Materials
APS	Automatic protection switching
IEC	International Electrotechnical Commission
HFC	Hybrid fibre-coaxial
MSAN	Multi-service access node
OGW	Overhead ground wire
OTN	Optical transport network
POI	Point of interconnection
QOS	Quality of service
SPD	Surge protective device

1 Introduction

1.1 Rationale

The destructive forces of natural and man-made disasters may impair, damage or destroy telecommunications networks. Additionally, the demand for telecommunications services usually soars before, during and after disasters. Therefore, it is vital that operators design reliability and robustness into their networks. Further to this, the required reliability and robustness with wired and wireless networks may differ.

In light of recent natural disasters and the resultant destruction of telecommunications networks in the Caribbean, the robustness of the national telecommunications infrastructure has become a critical issue. Compliance with appropriate technical standards will enable networks to better withstand the effects of natural and man-made disasters. The Telecommunications Authority of Trinidad and Tobago (the Authority) has a central role in establishing such standards.

1.2 Purpose

This document, *Technical Standards for Public Fixed Telecommunications Networks in Trinidad and Tobago*, establishes technical standards to enhance the robustness of public fixed telecommunications networks in Trinidad and Tobago, in relation to:

i. making the facilities within public fixed telecommunications networks resilient against natural and man-made disasters.

ii. implementing redundancy into key aspects of public fixed telecommunications networks.

This document does not deal with quality of service (QOS) standards for public fixed telecommunications networks.

1.3 Background

Given the importance of public fixed telecommunications networks as a means of communication, it is vital that these networks be designed and deployed to be resilient against natural and man-made disasters.

The access network in a public fixed telecommunications network infrastructure comprises outside plant facilities such as aerial cables, poles, manholes, underground ducts and cables, and cross-connect cabinets, as well as access network electronic devices such as multi-service access nodes (MSANs). Outside plant facilities, and MSANs in general, are in an external environment and are, therefore, susceptible to disasters.

The transport network and points of interconnection (POIs) are also critical parts of a public fixed telecommunications network that require a level of resilience and redundancy to ensure that they are not easily susceptible to catastrophic failure.

The Authority has noted past instances of network failures at POIs as well as destruction of aerial cables due to bush fires, vehicular accidents and falling trees/branches. These failures have led to service outages and other disruptions affecting large and small segments of the consumer population.

These key components of a public fixed telecommunications network should conform to appropriate technical standards to mitigate the effects of disasters. Additionally the appropriate technical standards should be applicable to the various types of public fixed telecommunications networks.

1.4 Objectives

This document:

i. identifies the detrimental effects of natural and man-made disasters on public fixed telecommunications network outside plant facilities.
ii. establishes technical standards for outside plant facilities to withstand the effects of natural and man-made disasters.
iii. establishes technical standards to enhance the resilience of active electronics within the access network of a public fixed telecommunications network.
iv. establishes technical standards to enhance the resilience of the optical transport network within a public fixed telecommunications network. **N.B.** Technical standards to enhance the resilience of a microwave transport network will be established in a later document.

v. establishes technical standards to enhance the resilience of POIs within a public fixed telecommunications network.

1.5 Relevant Legislation

The sections of the Telecommunications Act, Chap. 47:31 (the Act) which inform this document are:

Section (2)(1):

"In this Act –

"facility" means a physical component of a telecommunications network, other than terminal equipment, including wires, lines, terrestrial and submarine cables, wave guides, optics or other equipment or object connected therewith, used for the purpose of telecommunications and includes any post, pole, tower, standard, bracket, stay, strut, insulator, pipe, conduit, or similar thing used carrying, suspending, supporting or protecting the structure;"

Section (18)(1)(d):

"Subject to the provisions of this Act, the Authority may exercise such functions and powers as are imposed on it by this Act and in particular –

Establish national telecommunications industry standards and technical standards."

Section (25)(2)(a):

"In respect of a concessionaire's obligations pursuant to subsection (1), the Authority shall require a concessionaire to—

(a) comply with guidelines and standards established by the Authority to facilitate interconnection;"

Section (45):

(1) "Subject to the other provisions of this Act, concessionaires and licensees may implement such technical standards as they deem appropriate and which are in conformity with accepted international standards."

(2) *"Not withstanding subsection (1), the Authority may identify, adopt or establish preferred technical standards."*

1.6 Review Cycle

This technical standards document will be revised periodically to meet changing needs. The Authority will review the standards as necessary, and in consultation with stakeholders, to ensure that the document is guided by relevant international standards.

Questions or concerns regarding the maintenance of this document may be directed to the Authority via e-mail at consultation@tatt.org.tt.

1.7 Consultation Process

The Authority will seek the views of the general public and other stakeholders regarding this document and in accordance with its *Procedures for Consultation in the Telecommunications Sector of Trinidad and Tobago*. The document will be revised taking account of the comments and recommendations made during the consultation process.

The document will be made available for a first round of public consultation for a four-week period, as prescribed by the Authority's procedures. After reviewing public and stakeholder comments, the Authority will issue a revised document for a second round of public consultation for another four-week period. Comments received from the second round of consultation shall be reviewed and the final technical standards document shall be published thereafter.

1.8 Other Relevant Documents

Other relevant policies and regulations to be read along with the *Technical Standards for Public Fixed Telecommunications Networks in Trinidad and Tobago* include:

i. The Telecommunications Act, Chap. 47:31
ii. The *Authorisation Framework for the Telecommunications and Broadcasting Sectors of Trinidad and Tobago* (ver. 0.5)

1.9 Definitions

Access network: a system deployed between the local exchange and user premises, replacing part or the whole of the local line distribution network (ITU 2012)

Automatic protection switching: autonomous switching of a signal from a failed working trail/path to a protection trail/path, and subsequent restoration, using control signals (ITU 2004)

Man-made disaster: In the context of this document, this refers to a man-made event which negatively affects a small or large portion of a telecommunications network and, as a consequence, causes degradation or loss of service to a small or large number of consumers.

Multi-service access node: a platform which supports all the commonly deployed access technologies and services and acts as a gateway to a next generation network (NGN) core (Fujitsu n.d.)

Optical transport network: an optical transport network (OTN) comprises a set of optical network devices connected by optical fiber links. The OTN enables functions such as the transport, multiplexing, routing, management, supervision and survivability of optical channels carrying client signals (ITU 2004)

Point of interconnection: a point on the interconnection provider's network where physical connection is allowed to any interconnecting concessionaire to act as a gateway between networks, and enable the exchange of telecommunications services between networks (TATT 2006)

Public fixed telecommunications network: a system or any part thereof used for the provision of a public fixed (as distinct from mobile) telecommunications service.

1.10 Compliance Notation

"Standard"	The concessionaire is required to fully comply with the standard level as specified.
"Discretionary Standard"	There may exist valid reasons in particular circumstances where a standard cannot be implemented, but the full implications must be understood and the case carefully considered before choosing to ignore.

2 Disasters

2.1 Natural disasters

As part of the Caribbean, Trinidad and Tobago may experience any one of the following natural disasters:

i. **Hurricanes or strong winds**: A hurricane is a tropical cyclone that is generated over vast areas of warm water. Many hurricanes which affect the Caribbean region are formed in the Atlantic Ocean and, depending on the category of the hurricane, wind speeds can reach between 119 km/h to 250 km/h. Trinidad and Tobago, due to its location in relation to the equator, is not normally prone to hurricanes. The country, however, does experience tropical storms which cause damage to infrastructure.

ii. **Floods**: Flooding is the accumulation or overflow of a large amount of water over land which is normally dry (ODPM, Hazards - Flooding 2013). In Trinidad and Tobago, flooding normally occurs due to heavy rainfall during the rainy season from June to November. Deforestation and new developments in flood-prone areas have also exacerbated this problem. Many parts of the country are prone to flooding, including the capital city, Port of Spain.

iii. **Earthquakes:** An earthquake is the sudden shaking of the earth's crust caused by the shifting and unlocking of the tectonic plates that make up the earth's crust (ODPM 2013). The strength of an earthquake is indicated by the Richter magnitude which ranges from 0 to 9 (weakest to strongest). In recent years, earthquakes that affected Trinidad and Tobago reached a magnitude of 6.9 on the Richter scale. But due to the short duration, the long distance from the epicenter and/or the depth from which the earthquakes originated, the effects have not been severe.

iv. **Bush fires**: Bush fires occur during the dry season, which in Trinidad and Tobago is normally between December and May. Bush fires tend to occur alongside highways as well as on hilly slopes where slash and burn farming methods are utilised. The devastation caused by bush fires can be substantial if the fires are not extinguished quickly.

v. **Landslides**: Heavy or prolonged rainfall causes soil to become saturated and heavy. On sloped areas where there is hardly any vegetation, the pull of gravity causes saturated soil to slide down hills and develop into landslides. In Trinidad and Tobago, the heavy showers during the rainy season, combined with deforestation due to bush fires, development and slash and burn farming, cause areas located on steep slopes or at the base of mountains to become prone to landslides.

vi. **Lightning strikes**: A lightning strike is an electrical discharge which can occur either within a cloud, from cloud to cloud, or from cloud to ground, and are common during thunderstorms which occur during the rainy season.

vii. **Tsunamis**: A tsunami is a series of ocean waves of extremely long wavelength caused by underwater seismic activity. Tsunami waves can reach up to several metres high and can cover large areas up to a hundred thousand square kilometres (ODPM n.d.). In the past, Trinidad and Tobago has experienced very minor tsunamis, resulting in minimal damage to coastal areas.

2.2 Man-made disasters

Man-made disasters that affect public fixed telecommunications networks are identified below:

i. **Destruction of underground ducts and cables by unauthorised or unplanned excavation:** Unauthorised or unplanned excavation occurs with roadworks that are carried out without the requisite notifications and/or approvals from relevant authorities. During such excavations, roadwork equipment may penetrate underground telecommunications ducts, causing damage to cables.

ii. **Destruction of aerial telecommunications cables by vehicles:** Outside plant aerial telecommunications cables run either along the side of the road or from one side of the road to the other. Aerial telecommunications cables with low ground heights that cross from one side of the road to the other lie in the path of vehicles with highly elevated loads, for example, containers, cement or music trucks and land drilling rigs. The cables are therefore susceptible to being damaged.

iii. **Unauthorised burning of debris:** Flames caused by the burning of garbage and discarded items in residential areas may damage overhead aerial telecommunications cables.

iv. **Tree pruning:** The cutting of overhanging trees may result in branches falling on aerial telecommunications cables.

v. **Theft of copper aerial telecommunications cables:** Theft of copper aerial telecommunications cables occurs due to the high monetary value of copper.

vi. **Power outages**: Loss of electricity to facilities such as access nodes and buildings used to house network equipment.

vii. **Cutting of cables**: The malicious cutting of cable infrastructure.

viii. **Network traffic congestion**: The condition of a network where the immediate establishment of a new connection is impossible owing to the unavailability of network elements (Traffic Congestion 2000).

3 Technical Standards for Outside Plant facilities

Outside plant facilities consist of cabling as well as the infrastructure hardware that supports the cables. Outside plant facilities include:

i. aerial cables (fibre and copper) and associated passive devices (splitters, couplers and joints)
ii. poles
iii. manholes
iv. underground ducts
v. underground cables (fibre and copper) and associated passive devices
vi. twisted pair copper and fibre cabinets, and pedestals (no active electronics)

Technical standards aimed at mitigating the detrimental impacts of natural and man-made disasters on outside plant facilities are applied in this section.

3.1 Technical standards to mitigate the effect of natural disasters

3.1.1 Technical Standards for Aerial Telecommunications Cables

3.1.1.1 Hurricanes or Strong Winds

Vibration on telecommunications cables due to strong winds causes abrasion to the elements of the cable and potentially a break in the cable. Vibration suppressers should be installed at the ends of the cables to reduce the vibration. Cables with built-in strength members, and suspension wires lashed to aerial cables both further reduce vibration.

Connections between aerial cables should be protected from rain by ensuring that the enclosures remain waterproof. This is accomplished by following the proper installation, operational and maintenance procedures.

Utility poles supporting heavy loads, for example, electricity transformers, have a greater chance of breaking and falling during a hurricane than poles which do not support heavy loads. As far as practicable, aerial cables should not be connected to utility poles which support heavy loads.

Aerial cables could also become damaged if they are hit by falling branches or trees during hurricanes. Running cables underground is costly so it is suggested that branches be kept clear of telecommunications cables.

To mitigate the effects of hurricanes and strong winds on aerial telecommunications cables, the following are applied.

Technical standards to mitigate the effects of hurricanes or strong winds on aerial telecommunications cables:

(1) *Vibration dampers shall be installed between ends of aerial telecommunications cables and supporting structures* (ITU 2012).
(2) *Fibre optic cables shall either have a built-in strength member (element) or be lashed to a high-strength suspension/messenger wire* (ITU 2012).
(3) *In coastal areas as well as industrial areas, suspension/messenger wires shall be made of an anticorrosive material* (ITU 2012).
(4) *Enclosures used to house passive devices along aerial telecommunications lines shall be waterproof.*

Discretionary standards to mitigate the effects of hurricanes or strong winds on aerial telecommunications cables:

(1) *Aerial telecommunications cables should, as far as practicable, not be connected to utility poles which support heavy loads (for example, transformers). The exception should only occur when there is no other suitable pole available and a substitute pole cannot be planted.*
(2) *Aerial telecommunication cables should be kept clear of overhanging trees and branches.*

3.1.1.2 Lightning Strikes

Copper or fibre optic aerial cables with metallic elements or strands can be affected by lightning. Fibre optic cables without metallic elements or strands are not affected by lightning. Common ways of protecting aerial telecommunications cables from lightning strikes include: installation of an overhead ground wire (OGW) above the telecommunications cable with ample space between the conductor and the cable to prevent arcing; frequent grounding along the line of the telecommunications cable; grounding of metal strands along the line; and grounding of the cable at the point where the cable interfaces with a structure (ITU 2012). To mitigate the impact of lightning strikes on aerial telecommunications cables, the following are applied.

Technical standards to mitigate the effects of lightning strikes on aerial telecommunications cables:

(5) Aerial telecommunications cables shall be grounded along the cable route (ITU 2012).
(6) Surge protective devices (SPDs) shall be installed between the active conductors and the cable shield, with the shield connected directly to ground (ITU 2012).
(7) At points where aerial telecommunications cables enter or exit structures, the cable shall be grounded (ITU 2012) .
(8) OGWs shall be installed above aerial telecommunications cables (ITU 2012).
(9) OGWs shall be connected to ground (ITU 2012).

Discretionary standard to mitigate the effects of lightning strikes on aerial telecommunications cables:

(3) Hybrid fibre-coaxial (HFC) aerial plants — cables and strands — should be grounded every six pole spans or 300 meters.

3.1.1.3 Bush Fires

The heat generated from a bush fire may cause the sheath and the core of an aerial cable to melt. The use of cables made from non-flammable materials as well as the trimming of underlying bushes to a low height reduce the chances of aerial cables being damaged by bush fires. Service providers should ensure that underlying bushes are trimmed to a low height. To mitigate the impact of bush fires on aerial telecommunications cables, the following are applied.

Technical standard to mitigate the effects of bush fires on aerial telecommunications cables:

(10) Aerial telecommunications cables shall be made from non-flammable materials (ITU 2012).

Discretionary standard to mitigate the effects of bush fires on aerial telecommunications cables:

(4) In areas where aerial telecommunications cables are deployed, underlying bush and vegetation should be trimmed to a low height.

3.1.1.4 Tsunamis

Aerial telecommunications cables deployed within coastal areas are at risk of being damaged by tsunamis. Running cable routes at higher ground levels (as far as practicable) along coastal areas reduce the chances of aerial telecommunications cables being damaged by tsunamis. To mitigate the effects of tsunamis on aerial telecommunications cables, the following is applied.

Discretionary standard to mitigate the effects of tsunamis on aerial telecommunications cables:

(5) *As far as practicable, cable routes in coastal areas should be run at higher ground levels.* (ITU 2012).

3.1.2 Technical Standards for Telecommunications Poles

3.1.2.1 Hurricanes or Strong Winds

The use of guyed structures to keep telecommunications poles vertical and in place would reduce the impact of hurricanes on poles. In rural areas, guyed structures comprising guyed wires and guyed anchors should be used. In urban areas where space is restricted, sidewalk guys should be used. To mitigate the effects of hurricanes and strong winds on telecommunications poles, the following are applied.

Technical standards to mitigate the effects of hurricanes or strong winds on telecommunications poles:

(11) In rural areas, guyed structures comprising guyed wires and guyed anchors shall be used to support telecommunications poles.
(12) For corner poles and terminal poles, guyed wires shall be used.
(13) In areas where wind conditions are at the highest, guyed wires shall be attached to every second intermediate pole.
(14) Guyed anchors shall be used to attach guyed wires to the ground.
   i. Block type guyed anchors are used in soft ground.
   ii. Piton type guyed anchors are used in soft ground which has other installations/anchors buried in the ground.
   iii. Spikybolt type guyed anchors are used for rocky/concrete surfaces.
(15) In built up areas, sidewalk guyed structures shall be used to support telecommunications poles.

3.1.2.2 Bush Fires

As wood is a combustible material, telecommunications poles made of wood are susceptible to being burnt and destroyed by bush fires. The construction of firebreaks around these poles, particularly those deployed in rural areas prone to bush fires, reduces the chances of poles being destroyed by bush fires. To mitigate the effects of bush fires on telecommunications poles, the following is applied.

Discretionary standard to mitigate the effects of bush fires on telecommunications poles:

(6) Firebreaks should be constructed around the base of telecommunications poles, particularly those deployed in rural areas which are prone to bush fires (ITU 2012).

3.1.2.3 Earthquakes

Telecommunications poles have a great chance of falling during an earthquake if they are not buried deeply enough into the ground. The setting depth of a telecommunications pole is proportional to the length of the pole and should be equal to 10 % of the length of the pole plus an additional two feet (RedVector n.d.). In soft ground, extra support should be given to the setting of the pole via pole anchors (ITU 2014). To mitigate the effects of earthquakes on the poles, the following are applied.

Technical standards to mitigate the effects of earthquakes on telecommunications poles: *(16) The setting depth of telecommunications poles shall be 10% of the length of the pole plus an additional two feet* (RedVector n.d.).   *(17) Pole anchors shall be used for the burial of telecommunications poles in soft ground* (ITU 2012).

3.1.2.4 Landslides

Telecommunications poles installed at the base of slopes that are prone to landslides have a high chance of falling if the severity of a landslide is great. The planting of telecommunications poles in areas prone to landslides should be avoided and the telecommunications cables should be installed in underground ducts buried in the roadway. To mitigate the effects of landslides on telecommunications poles, the following are applied.

Discretionary standard to mitigate the effects of landslides on telecommunications poles: *(7) Telecommunications poles should not be installed in areas which are prone to landslides.*   *(8) If practicable, telecommunications cables should be run underground in ducts in areas prone to landslides.*

3.1.3 Technical Standards for Telecommunications Manholes

3.1.3.1 Earthquakes

During an earthquake, the soil around a manhole may liquefy. Liquefication of the soil will cause the manhole to move or sink and, as a result, may cause the underground duct and cable connections housed within the manhole to break. Soil liquefaction countermeasures applied during the deployment of manholes would reduce the chances of a manhole moving or sinking during an earthquake. To mitigate the effects caused by earthquakes on manholes, the following is applied.

Discretionary standard to mitigate the effects of earthquakes on telecommunications manholes:

(9) Liquefaction countermeasures should be applied during the deployment of telecommunications manholes (ITU 2012).

3.1.4 Technical Standards for Underground Ducts and Cables

3.1.4.1 Landslides

On hills where there is loose soil, rainfall may cause landslides, resulting in damage to underground ducts and cables buried within the soil. Underground ducts and cables should be buried under roadways in areas which are prone to landslides if practicable. Poles are more susceptible to landslides than ducts buried under roadways. To mitigate the effects caused by landslides on underground ducts and cables, the following is applied.

Discretionary standard to mitigate the effects of landslides on underground telecommunications ducts and cables:

(10) Underground ducts and cables should be buried under roadways in areas which are prone to landslides.

3.1.4.2 Floods

In times of flooding, underground duct and cable connections housed within manholes become vulnerable to water. By making underground ducts and cable connections waterproof, there is less likelihood of water penetrating underground cables. To mitigate the effects of flooding on underground ducts and cables, the following are applied.

Discretionary standard to mitigate the effects of floods on underground telecommunications ducts and cables:

(11) Excess gaps where underground ducts enter the manhole should be sealed using foam filler (ITU 2012).

(12) Joints connecting underground ducts and cables should be properly water sealed (ITU 2012).

3.1.4.3 Earthquakes

During an earthquake, underground ducts tend to move and flex due to the movement of the ground and, if the duct is too rigid, it can break. PVC or polyethylene (PE) duct sleeves and self-adjusting joints installed along the duct (where applicable), as well as at its ends, would allow a certain amount of movement and rotation to be accommodated throughout the duct. To mitigate the effects caused by earthquakes on underground ducts and cables, the following are applied.

Technical standards to mitigate the effects of earthquakes on underground telecommunications ducts and cables:

(18) Extendable joints shall be used along the lengths of the ducts (where applicable) as well as at the ends (ITU 2012).

(19) Underground ducts made of either PVC or high-density polyethylene (HDPE) shall be used (ITU 2014).

(20) The standard specification of the PE conduit that shall be used is ASTM F2160 for solid-wall high density polyethylene (HDPE) conduits (ITU 2014).

3.1.4.4 Tsunamis

To deploy underground ducts and cables across a bridge, the conduit is strapped and run along the bottom of the bridge from one side to the other. A tsunami would cause the height and force of water entering river mouths to increase and this, in turn, may damage the conduit strapped to the bridge. By running the conduit underneath the riverbed, the force of the water entering the river would be less detrimental to the conduit. To mitigate the effects of tsunamis on underground ducts and cables, the following is applied.

Discretionary standard to mitigate the effects of tsunamis on underground telecommunications ducts and cables:

(13) In coastal areas, conduits used to deploy telecommunications cables across bridges should be run underneath riverbeds (ITU 2012).

3.1.5 Technical Standards for Twisted Pair Copper Cabinets

3.1.5.1 Floods

Twisted pair copper cabinets are generally installed low to the ground and, as a result, are susceptible to being submerged due to flooding. Water may penetrate under the sleeves of the telecommunications cables terminated in the cabinet, thereby causing line degradation. The installation of twisted pair copper cabinets at sufficient heights above ground, as well as outfitting the cabinets with waterproof doors, reduces the chances of twisted pair copper cabinets being submerged due to flooding. In areas that are prone to flooding, twisted pair copper cabinets should be installed on H-frames. Pedestals used to house passive devices like taps, nodes and couplers should be water sealed. To mitigate the damage caused by floods on twisted pair copper cabinets, the following are applied.

Technical standards to mitigate the effects of floods on twisted pair copper cabinets:

(21) Cross-connect cabinets shall be installed on concrete foundations which are, at a minimum, six inches above ground level.
(22) Cross-connect cabinets shall be outfitted with waterproof doors.
(23) In areas that are prone to flooding, cross-connect cabinets shall be installed on H frames at a sufficient height above known floodwater levels.
(24) Pedestals shall be kept waterproof.

3.1.5.2 Tsunamis

Within coastal areas, twisted pair copper cabinets are susceptible to damage by tsunamis. The installation of twisted pair copper cabinets at higher ground (where practicable), or on H frames along coastal areas would reduce the chances of twisted pair copper cabinets being damaged by tsunamis. To mitigate the effects of tsunamis on twisted pair copper cabinets, the following is applied.

Discretionary standard to mitigate the effects of tsunamis on twisted pair copper cabinets:

(14) In coastal areas, cross connect cabinets should be installed at higher ground (where practicable) or on H frames at a sufficient height above the ground.

3.2 Technical Standards to mitigate the effect of man-made disasters

3.2.1 Technical Standards for Underground Ducts and Cables

Concrete encasements constructed below the ground surface to cover the tops of underground ducts would reduce the chance of damage caused to underground ducts and cables during unauthorised or unplanned excavations. These concrete encasements should be implemented for underground ducts which are buried less than 30 inches below the surface (United States department of agriculture 2002). To prevent damage to underground telecommunications ducts and cables by unauthorized or unplanned excavations, the following is applied.

Discretionary standard to mitigate the damage caused to underground ducts and cables by unauthorized or unplanned excavations:

(15) For underground ducts which are buried less than 30 inches below street level, concrete encasements covering the top of the duct should be constructed (United States department of agriculture 2002).

3.2.2 Technical Standards for Aerial Telecommunications Cables

3.2.2.1 Destruction by vehicles

Aerial telecommunications cables may become damaged if they come into contact with high vehicles. The height of aerial cables from the ground, inclusive of sag, should be a minimum of 15 feet, five inches, where practicable, to allow sufficient clearance for high vehicles. To mitigate the damage caused by vehicles to aerial telecommunications cables, the following is applied.

Discretionary standard to mitigate the damage caused by high vehicles to aerial telecommunications cables:

(16) Where practicable, the minimum ground height of aerial telecommunications cables running across roads (inclusive of sag) should be 15 feet, five inches (15 ft 5 in) (Coldrocks n.d.).

3.2.2.2 Unauthorised burning of debris

The burning of debris or rubbish on roadsides may result in damage to low-hanging aerial telecommunications cables. The ground height of aerial cables running along the sides of roads should be a minimum of 15 feet, five inches, as well as cables should be made from non-flammable materials to reduce the possibility of damage to aerial telecommunications cables by burning debris. To mitigate the damaging effects caused by the burning of debris to aerial telecommunications cables, the following are applied.

Technical standard to mitigate the damage caused by the burning of debris to aerial telecommunications cables:

(25) Aerial telecommunications cables shall be made from non-flammable materials.

Discretionary standard to mitigate the damage caused by the burning of debris to aerial telecommunications cables:

(17) Minimum ground height of aerial telecommunications cables running along the sides of roadways (inclusive of sag) should be 15 feet, five inches (Coldrocks n.d.).

3.2.2.3 Tree pruning

The trimming of tree branches hanging over aerial telecommunications cables may result in cables being damaged if falling branches hit them. Tree branches located near aerial telecommunications cables should be trimmed by personnel or contractors authorised by the operators, thereby reducing the probability of damage to aerial cables caused by falling branches. To mitigate the damage caused by tree pruning to aerial telecommunication cables, the following is applied.

Discretionary standard to mitigate the damage caused by tree pruning on aerial telecommunications cables:

(18) Overhanging branches close to aerial telecommunications cables should be kept trimmed by personnel or contractors authorised by operators to do so.

3.2.2.4 Theft of copper aerial telecommunications cables

There has been a significant number of instances where copper aerial telecommunications cables have been cut and stolen. In areas prone to such theft, these cables should, as far as practicable, be run in underground ducts. To mitigate the theft of copper aerial telecommunications cables, the following is applied.

Discretionary standard to mitigate the theft of copper aerial telecommunications cables:

(19) In areas prone to theft of copper aerial telecommunications cables, these cables should, as far as practicable, be run in underground ducts.

4 Technical Standards to Enhance the Resilience of the Access Network (Active Electronic Devices)

Access network active electronic devices such as multi-service access nodes (MSANs) are located either in controlled buildings (if available) or in outdoor cabinets. Outdoor cabinets used to house MSANs should be designed with consideration being made to the following elements: environmental protection and related sealing requirements, mechanical protection, thermal management, electrical powering (ITU 2007), and protection against theft. To enhance the resilience of access network active electronic devices such as MSANs, the following are applied.

Technical standards to enhance the resilience of access network active electronic devices:

(26) For outdoor cabinets used to house multi-service access nodes (MSANs), protection against dust and resistance against jets of water shall be applied at a minimum, in accordance with international protection 55 of the specification IEC 60529 (ITU 2007).

(27) Outside cabinets used to house MSANs shall be able to withstand 20.00 joules of impact energy, in accordance with IK code 10 of the specification IEC 62262 (ITU 2007).

(28) The temperature within the structure used to house MSANs shall always be within the operational temperature range of the equipment (ITU 2007).

(29) Each structure used to house MSANs shall be wired to accommodate back up power (ITU 2007).

(30) Outdoor cabinets used to house MSANs shall be properly secured.

(31) Back-up power generators shall, without refueling, have the capability of supporting full equipment load and building ancillary services load for a period of eight to 12 hours to buildings which house MSANs.

(32) A supply of fuel capable of running standby generators (if deployed) for one week shall be on site at buildings which house MSANs.

(33) Back-up power batteries or fuel cell technology shall have the capability of supporting full equipment load for a minimum period of six hours to outdoor cabinets which house MSANs.

5 Technical Standards for Optical Transport Networks

Technical standards to enhance the resilience of optical transport networks (OTNs) are applied in this section.

5.1 Technical Standards to Implement Redundancy

The most common mode of redundancy deployed in OTNs is ring topology. If there is a break in one of the spans of the ring, the signal is transmitted through the opposite direction of the ring to the destination node. In a single fibre ring topology, two separate breaks in the fibre within different spans of the ring may prevent a signal from reaching its destination node. By utilising a second fibre within the ring to act as a protective fibre, signals can be switched from the broken fibre to the protective one using automatic protection switching (APS) to reach the destination node (ITU 2014). Redundancy is also required during occurrences when equipment gets damaged. In times like these, spare equipment should be readily available so that operations can be restarted with minimal downtime. To implement redundancy within OTNs, the following are applied.

Technical standards to implement redundancy in optical transport networks (OTNs):

(34) Ring topologies shall be deployed within OTNs.
(35) For large public fixed telecommunications operators, two physically diverse paths equipped with APS shall be deployed within their OTN ring topologies.
(36) Spare critical equipment shall be readily available.

5.2 Technical Standards to Withstand the Effects of Natural and Man-made Disasters

OTN devices are generally housed in either a building or shelter. Structures used to house OTN devices should be constructed to withstand the effects of hurricanes and earthquakes, as well as be resilient against man-made disasters such as power outages and malicious damage to cable infrastructure connected to the structure or equipment. To mitigate the effects of natural and man-made disasters on OTN nodes, the following are applied.

Technical standards to mitigate the effects of both natural and man-made disasters on optical transport network (OTN) nodes:

(37) Buildings that house OTN nodes shall comply with the building codes adopted in Trinidad and Tobago.

(38) Shelters that house OTN nodes shall be designed to withstand hurricanes up to Category 5.

(39) Shelters housing OTN nodes shall be designed to withstand earthquakes up to a magnitude of 7 on the Richter scale.

(40) Structures that house OTN nodes shall be constructed with two physically separate cable entrances.

(41) Structures housing OTN nodes shall be equipped with stand-by power facilities and batteries.

(42) Stand-by power facilities shall have the following features:

- *I. Automatic load transfer*
- *II. Capability of supporting full equipment and building ancillary services loads for a period of one week without refueling*

Discretionary standard to implement redundancy in optical transport network (OTNs):

(20) Where practicable, opposite sides of the OTN ring topology should be run on opposite sides of the road in areas where there is no readily available diverse physical path.

6 Technical Standards for Points of Interconnection or Switches

Technical standards to enhance the resilience of POIs are applied in this section.

6.1 Technical Standards to Implement Redundancy

In the past, technical issues at a POI have caused disruption in the telecommunications services between the operators served by that POI. A second POI acting as a redundant POI eliminates or significantly reduces the duration of the disruption of inter-operator traffic between operators. To mitigate the effects caused by technical failures at a POI, the following is applied.

Technical standards to implement redundancy to points of interconnection (POIs):

(43) Public fixed telecommunications operators from whom interconnection services are requested shall have two separate POIs.

6.2 Technical Standards to Withstand the Effects of Natural and Man-made Disasters

POI equipment is normally housed in local exchanges, trunk exchanges, or international exchanges belonging to the corresponding operator(s). Considering the vital need for telecommunications services between operators in times of emergency, buildings which house POIs should be constructed to be resilient against both natural disasters, such as hurricanes and earthquakes, and man-made disasters such as power outages.

In times of natural disasters, telecommunications networks become congested, causing overloading of the switching network. Features such as congestion detection and traffic control functionality within the switching network, and emergency voice call prioritization should be applied to control network congestion (ITU 2017).

To mitigate the effects of natural and man-made disasters on buildings used to house POIs, the following are applied.

Technical standards to mitigate the effects of natural and man-made disasters on buildings used to house points of interconnection (POIs):

(44) Buildings which house POIs shall comply with the building codes adopted in Trinidad and Tobago.

(45) Switches shall be installed with congestion detection and traffic control functionality.

(46) Switches shall have the functionality to prioritise calls to emergency services.

(47) Buildings that house POIs shall have stand-by power facilities.

(48) Stand-by power facilities shall have the following features:

I. Automatic load transfer feature

II. Capability of supporting full equipment and building ancillary services loads for a period of one week without refueling

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