Telecommunications Authority of Trinidad and Tobago

Technical Standards for Wireless Networks

January 2023

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Maintenance History		
Date	**Change Details**	**Version**
1st October 2021	Consultative document for first round of public consultation	0.1
15th August 2022	Consultative document for second round of public consultation	0.2
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Abbreviations

ANSI	American National Standards Institute
BWA	broadband wireless access
EGB	external ground bus bar
e-NodeB	evolved node B
EPC	evolved packet core
FTA	free-to-air
IEC	International Electrotechnical Commission
RBS	radio base station
TIA	Telecommunications Industry Association
QoS	quality of service
STL	studio-to-transmitter link
OTN	optical transport network
RF	radio frequency
UHF	ultra-high frequency
VHF	very high frequency

1. Introduction

1.1 Background

In 2019, the Authority, pursuant to the provisions of the Telecommunications Act, Chap. 47:31 (the Act), and in collaboration with public fixed telecommunications operators through a technical working group (TWG), developed the *Technical Standards for Public Fixed Telecommunications Networks*, in which mandatory and discretionary technical standards were established to mitigate the effects of natural and man-made disasters on public fixed telecommunications networks. These standards were deemed necessary given the damage caused by natural disasters throughout the Caribbean. This includes the impact of Hurricane Irma on telecommunications infrastructure in Barbuda, the British Virgin Islands and Turks and Caicos, and the destruction caused by Hurricane Maria to telecommunications infrastructure in Dominica and Puerto Rico. Both of these hurricanes occurred in 2017.

Similar to public fixed telecommunications networks, wireless networks comprise facilities that are susceptible to natural and man-made disasters, and include cellular mobile networks, free-to-air (FTA) broadcasting stations, broadband wireless access (BWA) networks, and land mobile and point-to-point radiocommunications systems. It is vital that wireless facilities, through the implementation of appropriate technical standards, be sufficiently resilient to disasters, whether due to natural or man-made causes. In developing relevant standards for public wireless networks in 2021, the Authority also utilised a TWG of wireless operators for assistance.

Facilities like cellular sites comprise outdoor radio cabinets or buildings used to house telecommunications equipment, and towers (or poles) including mounted antennas, cables and cable accessories. A cellular site is vulnerable during natural disasters like lightning strikes, earthquakes, bush fires, hurricanes and floods, and man-made disasters such as power outages and malicious damage to infrastructure or equipment. Broadcasting transmitter sites also comprise buildings that house communications equipment and towers with mounted equipment and are therefore vulnerable to natural disasters, such as lightning strikes, earthquakes, hurricanes and floods, and man-made disasters, such as power outages, malicious damage to cables, and collision of aircraft with towers.

Studio-to-transmitter links (STLs) generally use point-to-point radiocommunications, whilst transport networks within a wireless network utilise either point-to-point microwave or fibre optic links as the medium. Point-to-point links are susceptible to natural disasters, such as lightning strikes, earthquakes and hurricanes. Likewise, fibre optic links, particularly aerial cable routes, are at risk from natural disasters, including bushfires. Radiocommunications equipment located within

industrial environments are also at risk from industrial accidents or events, which may lead to the disruption of a public telecommunications service.

1.2 Purpose

The purpose of this document, *Technical Standards for Wireless Networks*, is to ensure that service is maintained as far as possible throughout a natural disaster and to minimise the time that consumers are without service prior to restoration, by establishing wireless network facilities standards aligned with local and international industry best practices.

1.3 Objectives

The document:

1. identifies the detrimental effects of natural and man-made disasters on wireless networks.

2. establishes technical standards:

    a) to enable wireless network equipment and facilities to minimise these detrimental effects.

    b) to enhance resiliency for key areas within wireless networks.

1.4 Scope

This document covers hazards from natural and man-made disasters of a physical nature. It does not address concerns with cyberattacks as a man-made disaster, nor provide standards to mitigate the effects of cyberattacks on wireless networks.

Additionally, the document does not deal with quality of service (QoS) standards for wireless networks.

1.5 Relevant Legislation

The sections of the Act that 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 for carrying, suspending, supporting or protecting the structure;

Section (3)(b):
The objects of the Act are to establish conditions for—

the facilitation of the orderly development of a telecommunications system that serves to safeguard, enrich and strengthen the national, social, cultural and economic well-being of the society;"

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 (35):

Where trees on private lands overhang or interfere with any facility or road works, a concessionaire shall, before cutting down, pruning or trimming the trees, obtain the consent of the owner or person in possession of the land.

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) Notwithstanding subsection (1), the Authority may identify, adopt or establish preferred technical standards.

1.6 Review Cycle

This document will be revised every four years. The Authority will review it and, if necessary, make modifications, in consultation with stakeholders, to ensure that the standards are guided by appropriate international standards and local best practices.

Questions or concerns regarding the maintenance of this document may be directed to the Authority via email at info@tatt.org.tt.

1.7 Consultation Process

In accordance with its *Procedures for Consultation in the Telecommunications Sector of Trinidad and Tobago (version 7.0, 2021)*, the Authority sought the views of the general public and industry stakeholders on the first draft of this document, published on 11th October 2021, with an initial closing date of 15th November 2021. The closing date was extended to 6th December 2021, following requests from stakeholders.

The Authority again sought the views of the general public and industry stakeholders on the second consultative document, published on 15th August 2022, with an initial closing date of 12th September 2022. The closing date was extended to 26th September 2022, following requests from stakeholders.

The comments and recommendations received from the second round of consultation, and the Authority's decisions on these comments and recommendations, have been compiled in the DORs in Appendix I.

Based on the comments and recommendations received from the second round of public consultation, the following revisions were made to version 0.2 of the document:

1. A definition for "RF traffic channel utilisation" has been included in section 1.9.
2. A definition for "core network" has been included in section 1.9.
3. Mandatory standard 4 has been amended.
4. Mandatory standard 21 has been amended.
5. Mandatory standard 28 has been amended.
6. Mandatory standard 38 has been amended.
7. Other minor revisions were made for readability.

1.8 Other Relevant Documents

Other relevant policies, documents and regulations to be read along with the *Technical Standards for Wireless Networks* include:

1. The Telecommunications Act, Chap. 47:31

2. The *Authorisation Framework for the Telecommunications and Broadcasting Sectors of Trinidad and Tobago (2005 or relevant subsequent updates)*

3. *Technical Standards for Public Fixed Telecommunications Networks (2020 or relevant subsequent updates)*

1.9 Definitions

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Class 1, Division 1 location: This is an industrial location in which ignitable concentrations of flammable gases, vapours or liquids:

1. can exist under normal operating conditions.

2. may exist frequently because of repair or maintenance operations or leakage.

3. may exist because of equipment breakdown that simultaneously causes the equipment to become a source of release (UL 2022 or relevant subsequent updates).

Class 1, Division 2 location: This is an industrial location:

1. in which volatile flammable liquids or flammable gases or vapours exist but are normally confined within closed containers.

2. in which ignitable concentrations of gases, vapours or liquids are normally prevented by positive mechanical ventilation.

3. adjacent to a Class I, Division 1 location where ignitable concentrations might be occasionally communicated (UL 2022 or relevant subsequent updates).

Controlled site: In the context of this document, a controlled site refers to a site where communications equipment is housed and the entrance to the site is controlled by the owner or occupant of the site.

Core network: The backbone of a telecommunications network that provides services such as authentication and call control to customers connected by the access network[1]

External ground bus bar (EGB): A ground bus bar that provides a bonding point for multiple grounding conductors (such as all coaxial connections) and connection to the grounding electrode system (Motorola 2005 or relevant subsequent updates)

Lightning protection system (LPS): A complete system used to reduce physical damage due to lightning flashes to a structure (ITU, K.112 2019 or relevant subsequent updates)

Man-made disaster: In the context of this document, this refers to an event caused by human activity, which negatively affects a wireless network, and consequently causes degradation or loss of service.

Packet data traffic utilisation: The ratio of the cumulative utilised packet data resource elements (Res) on the eNodeBs and EPC to the available packet data resources in an LTE mobile network (ITU, E.811 2017 or relevant subsequent updates), or the comparable elements in a non-LTE mobile network

Radio base station (RBS): An installation intended to provide access to the telecommunications system by means of radio waves (ITU, K.56 2010 or relevant subsequent updates)

RF traffic channel utilisation: The ratio of the cumulative occupation of RF traffic channels on the access network to the available RF traffic channels in a specific cell (ITU, E.811 2017 or relevant subsequent updates)

Transmitter: A device that converts baseband signals to an RF VHF/UHF broadcasting signal and amplifies it to a level required to drive the antenna system (National Association of Broadcasters Engineering Handbook. 10th. 2013 or relevant subsequent updates)

Transport network: In the context of this document, this refers to the portion of a public telecommunications network that is between the core and the access network, and for broadcasting,

[1] Based on definitions from Ofcom https://www.ofcom.org.uk/__data/assets/pdf_file/0013/63220/nga_glossary.pdf, GSMA GSMA | GSMA Glossary of Aviation and Mobile Terms | Internet of Things, and the European Commission Glossary: Core network (CN) | CROS (europa.eu), for Core Network

between the broadcasting studio and the transmitter, which is commonly known as a studio-to-transmitter link (STL).

Zone 0 environment: An industrial space where ignitable concentrations of flammable gases, flammable liquid-produced vapours, or combustible liquid-produced vapours are present continuously or for long periods of time under normal operating conditions (UL 2022 or relevant subsequent updates)

Zone 1 environment: An industrial space where ignitable concentrations of flammable gases, flammable liquid-produced vapours, or combustible liquid-produced vapours are likely to exist under normal operating conditions (UL 2022 or relevant subsequent updates)

Zone 2 environment: An industrial space where ignitable concentrations of flammable gases, flammable liquid-produced vapours, or combustible liquid-produced vapours are not likely to exist under normal operating conditions (UL 2022 or relevant subsequent updates)

1.10 Compliance Notation

The technical standards stated in this document are classified as either mandatory or discretionary. Mandatory and discretionary standards are defined as follows:

Mandatory Standard	The licensee shall comply fully with the standard as specified.
Discretionary Standard	The licensee may comply with the standard as specified. There may exist valid reasons in particular circumstances where the specified standard cannot be implemented; in such instances, if the licensee chooses not to comply with the standard, the full implications of the case must be understood and carefully considered by the licensee.

2 Disasters

2.1 Natural Disasters

Trinidad and Tobago may experience any one of the following natural disasters:

1. **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 along highways, as well as on hilly slopes where slash-and-burn farming methods are used. If bush fires are not extinguished quickly, the devastation they cause can be substantial.

2. **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 crust (ODPM, Hazards - Earthquakes 2013 or relevant subsequent updates). The strength of an earthquake is indicated by Richter magnitudes which range 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.

3. **Floods**: Flooding is the accumulation or overflow of a large amount of water over land which is normally dry (ODPM, Hazards - Flooding 2013 or relevant subsequent updates). 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 exacerbated this problem. Many parts of the country are prone to flooding.

4. **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 and 251 km/h. Trinidad and Tobago, due to its location in relation to the equator, is not normally prone to hurricanes.

5. **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 the 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.

6. **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 in the rainy season.

7. **Mud volcanoes**: A mud volcano is a mound of mud with craters in the earth's surface through which erupting gas and vapour causes mud to boil and occasionally overflow. In Trinidad and Tobago, there are 15 mud volcanoes, with two of the biggest and most active located in Piparo and Devil's Woodyard, Princes Town.

8. **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 2022 or relevant subsequent updates).

2.2 Man-Made Disasters

Man-made disasters that affect wireless communications networks are identified below:

1. **Aircraft collision with towers**: An incident involving the collision of an aircraft with a tower

2. **Building fires:** Fires within buildings caused by malicious activity or faulty equipment

3. **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. Cables with low ground heights that cross from one side of the road to the other lie in the path of vehicles with elevated loads, for example, containers, cement or music trucks and land-drilling rigs. These cables are, therefore, susceptible to being damaged.

4. **Destruction of underground ducts and cables by unauthorised or unplanned excavation**: Unauthorised or unplanned excavation occurs during 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 the cables.

5. **Industrial incident/accident**: An industrial-related event that affects the working or natural environment and causes injury, illness and/or property damage

6. **Network traffic congestion**: Network traffic congestion occurs when the amount of data to be transmitted exceeds the capacity of the available bandwidth, which may have an adverse effect on network operation.

7. **Power outages**: Loss of electricity to facilities such as cellular sites or buildings used to house radiocommunications equipment

8. **Sabotage**: Malicious damage to radiocommunications facilities

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

10. **Unauthorised burning of debris**: Fire from the burning of garbage and discarded items in residential areas may damage overhead aerial telecommunications cables.

3 Technical Standards for Wireless Networks

3.1 Wireless Network Equipment and Facilities

Wireless networks comprise equipment and facilities that are susceptible to natural and man-made disasters. Such facilities include the following:

1. Structures that house communications equipment
2. Radiocommunications towers and antennas
3. Wireless access networks
4. Core networks
5. Transport networks
6. Radiocommunications equipment located in industrial environments
7. Broadcasting transmitters including STLs

Technical standards to mitigate the effects of natural and man-made disasters on these network facilities would apply to networks that have already been constructed and are in operation. A suitable timeframe for the implementation of the standards into existing networks will be prescribed in consultation with the operators. New wireless networks or new additional facilities within an existing wireless network are required to conform to these standards at the time of implementation.

3.2 Technical Standards to Mitigate the Effects of Natural Disasters

In this section, technical standards to mitigate the effects of natural disasters on wireless network equipment and facilities are established.

3.2.1 Technical Standards for Equipment Housed at Communications Sites

3.2.1.1 Lightning Strikes

3.2.1.1.1 Communications Equipment Housed in Buildings

Communications equipment is generally housed in buildings or outdoor cabinets located in a controlled site. To protect the equipment from lightning strikes, the installation of a lightning protection system (LPS) is required. The ground of the LPS is connected to the grounds of other aspects of a communications site, such as the AC power system, tower, telephone system, building,

underground metallic piping systems and fencing, forming a single grounding electrode system. Ground rods, ground plates or, where there is underlying bedrock, grounding conductors are buried in the ground and connected to the site grounding electrode system. A ground ring is installed around the building and connected to both the steel reinforcement of the building and the external ground bus bar (EGB) located on the outside of the building. Equipment racks, ducts and trays located within the building are grounded and bonded to the building ground ring using grounding conductors. The building ground ring is connected at a minimum of 2 points to the grounding ring of the tower. Throughout the radiocommunications industry in Trinidad and Tobago, the grounding standards in the *Motorola R56 Standards and Guidelines for Communication Sites* (Motorola 2005 or relevant subsequent updates) have been commonly adopted by the relevant operators, as indicated by the TWG. To mitigate the effect of lightning strikes on communications equipment operated by concessionaires and licensees that is housed in buildings, the following standard is applied.

Mandatory Standard to Mitigate the Effects of Lightning Strikes on Communications Equipment Operated by Concessionaires and Licensees that is Housed in Buildings:

(1) The electrical grounding of communications equipment that is housed in buildings shall comply with, at a minimum or better, the internal grounding standards stated in chapter 5 of the Motorola R56 - Standards and Guidelines for Communication Sites (Motorola 2005 or relevant subsequent updates).

3.2.1.1.2 Rooftop Radio Base Station

A rooftop radio base station (RBS) includes an antenna located on the roof of a building, and the electronic communications equipment located either on the roof or in an equipment room in the building. In some instances, the operator who owns the rooftop RBS may be given permission by the owner of the building to directly connect the antenna mast and RBS equipment to the building's grounding electrode system. This bonding of the communications equipment and mast to the building's grounding electrode system is done via a minimum of two bonding points. If direct connection to the building's grounding electrode system is not possible, an LPS should be installed on the roof, with the antenna mast and RBS equipment bonded to the LPS. The LPS is then connected to the building's main roof perimeter lightning protection ring. The antenna mast has a lightning rod installed at the top, with the top of the rod being a minimum of 30 centimetres above the top of the antennas. The mast, which is normally metallic, acts as an air-termination system. RBS equipment located within an equipment room is also bonded to the building's grounding network. To mitigate the effects of lightning strikes on a rooftop RBS, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Lightning Strikes on Rooftop Radio Base Stations:

(2) Electrical grounding of a rooftop RBS mast and equipment shall comply with, at a minimum or better, the grounding standards in sections 4.9 and 5.9 of the Motorola R56 Standards and Guidelines for Communication Sites (Motorola 2005 or relevant subsequent updates).

(3) The top of the lightning rod installed on the mast shall be, at a minimum, 30 centimetres above the antennas of the rooftop RBS (ITU, K.112 2019 or relevant subsequent updates).

3.2.1.2 Bush Fires

Buildings or controlled sites in which communications equipment is housed need to be protected from bush fires. To minimise the risk of a bush fire damaging the structure or controlled site, and furthermore, the communications equipment, firebreaks are to be constructed, where practicable, around the perimeter of communications sites and outdoor cabinets constructed using fireproof material. Dry branches, leaves and paper are flammable, so the outside of structures and sites used to house communications equipment are to be kept free of flammable materials and clear of overgrown vegetation. To mitigate the effects of bush fires on structures that house communications equipment, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Bush Fires on Structures that House Communications Equipment Operated by Concessionaires and Licensees:

(4) Outdoor cabinets used to house communications equipment shall be constructed to ensure fire retardancy.

(5) The area around the site that houses communications equipment shall be kept clear of litter and flammable materials.

Discretionary Standards to Mitigate the Effects of Bush Fires on Structures that House Communications Equipment Operated by Concessionaires and Licensees:

(1) Where practicable, particularly in rural areas which are prone to bush fires, firebreaks should be constructed outside and around the perimeter of sites that house communications equipment.

(2) The width of the firebreak should be appropriate for the type of firebreak implemented, as follows:

a) For ploughed firebreaks, the minimum width of the fire break should be one metre (USDA, National Resources Conservation Services 2006 or relevant subsequent updates).

b) For mowed or bladed firebreaks, the minimum width of the firebreak should be two metres (USDA, National Resources Conservation Services 2006 or relevant subsequent updates).

3.2.1.3 Hurricanes

Buildings and outdoor cabinets used to house communications equipment need to be designed and installed to withstand the effects of hurricanes. To mitigate the effects of hurricanes on structures used to house communications equipment, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Hurricanes on Structures that House Communications Equipment Operated by Concessionaires and Licensees:

(6) Buildings that house communications equipment shall comply with the relevant building codes adopted for use in Trinidad and Tobago.

(7) The anchoring of outdoor cabinets that house communications equipment shall, at a minimum, comply with the standards related to the anchoring of cabinets in section 9 of the Motorola R56 Standards and Guidelines for Communication Sites (Motorola 2005 or relevant subsequent updates).

Mandatory Standards to Mitigate the Effects of Hurricanes on Structures that House Communications Equipment Operated by Concessionaires and Licensees (cont.):

(8) Outdoor cabinets that house RBS electronic communications equipment shall, at a minimum, have protection against dust and resistance against jets of water, in accordance with international protection (IP) 55 of the specification IEC 60529 (ITU, L.70 2007 or relevant subsequent updates).

(9) Outdoor cabinets that house RBS electronic communications equipment shall be able to withstand 20 joules of impact energy, in accordance with IK code 10 of the specification IEC 62262 (ITU, L.70 2007 or relevant subsequent updates).

3.2.1.4 Earthquakes

Buildings and outdoor cabinets that house communications equipment need to be constructed to withstand the effects of earthquakes. To mitigate the effects of earthquakes on structures that house communications equipment, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Earthquakes on Structures that House Communications Equipment Operated by Concessionaires and Licensees:

(10) Buildings that house communications equipment shall comply with the relevant building codes adopted for use in Trinidad and Tobago.

(11) The anchoring of outdoor cabinets that house communications equipment shall, at a minimum, comply with the seismic consideration standards in section 9 of the Motorola R56 Standards and Guidelines for Communication Sites (Motorola 2005 or relevant subsequent updates)

3.2.1.5 Floods

During the peak of the rainy season, certain parts of Trinidad and Tobago are known to flood. As a result, it is critical that structures used to house communications equipment, particularly those located in areas prone to flooding, be constructed to withstand the effects of floods. Maps that show flood-prone areas throughout Trinidad and Tobago can be found on the websites of the Office of Disaster Preparedness and Management (ODPM) and the Tobago Emergency Management Agency (TEMA). To mitigate the effects of flooding, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Floods on Structures Used to House Communications Equipment Operated by Concessionaires and Licensees:

(12) In areas prone to flooding, buildings that house communications equipment shall be constructed at a sufficient height above known floodwater levels.

(13) In areas prone to flooding, outdoor cabinets that house communications equipment shall be installed on concrete pads at a sufficient height above known floodwater levels.

(14) Outdoor cabinets that house communications equipment shall be outfitted with water-resistant doors.

3.2.1.6 Mud Volcanoes

Although there are only a few mud volcanoes in Trinidad and Tobago, the major ones are located within populated areas for which telecommunications coverage to service the residents will be needed, particularly during and after a natural disaster. The heavy flow of mud caused by an immense mud volcano eruption may damage telecommunications infrastructure, such as cell sites. Along with the damage to telecommunications infrastructure, the mud may also make roads impassable and, if volcanic gas is released over a long period, maintenance activities at nearby cell sites may be hindered. To mitigate the effects of mud volcanoes on structures used to house communications equipment, the following standards are applied.

Mandatory Standard to Mitigate the Effects of Mud Volcanoes on Structures Used to House Communications Equipment Operated by Concessionaires and Licensees:

(15) In areas prone to mud volcanoes, perimeter walls shall be built around structures used to house communications equipment.

Discretionary Standard to Mitigate the Effects of Mud Volcanoes on Structures Used to House Communications Equipment Operated by Concessionaires and Licensees:

(3) As far as practicable, structures used to house communications equipment should not be located in close proximity to a mud volcano.

3.2.2 Technical Standards for Radiocommunications Towers and Antennas

3.2.2.1 Lightning Strikes

Radiocommunications towers, which include self-supporting towers, guyed towers and monopoles, also need to be protected from lightning strikes. Towers and structures that are used to house communications equipment are linked via cables that enter the building from the tower. If lightning strikes the tower, the dispersed energy could run through the cables and enter the structure. Therefore, a separate grounding system is installed on the tower to ground the energy, preventing it from entering the structure. At intervals along the tower, the cable that connects the equipment to the antenna is bonded to the grounding conductor of the tower.

A ground ring, which is connected to buried earthing rods, is constructed around the base of the tower, with elements such as the tower mast (for monopole towers), tower legs (for lattice towers), vertical grounding conductor (for poles) and tower plates (for guyed towers) connected to the ground ring. Guyed cables and anchors are also connected to earthing rods buried in the ground. The tower ground is connected to the ground ring installed around the structure used to house the communications equipment. The part of the cable bridge that runs vertically along the tower is connected to the tower using a nonconductive device. The horizontal part of the cable bridge located between the tower and the structure is bonded to the grounding electrode system of the site via the EGB, which is located on the outside of the building, with the supporting legs of the cable bridge bonded to the grounding electrode system using conductors. To mitigate the effects of lightning strikes on radiocommunications towers and mounted antennas, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Lightning Strikes on Radiocommunications Towers and Antennas:

(16) Radiocommunications towers/poles shall be grounded, at a minimum or better, in compliance with the external grounding (earthing) standards for towers in chapter 4 of the Motorola R56 Standards and Guidelines for Communication Sites (Motorola 2005 or relevant subsequent updates).

Mandatory Standards to Mitigate the Effects of Lightning Strikes on Radiocommunications Towers and Antennas (cont.):

(17) Lightning rods that are installed on radiocommunications towers shall comply with the standards in section 2.12.2.5 of the Motorola R56 Standards and Guidelines for Communication Sites (Motorola 2005 or relevant subsequent updates)

3.2.2.2 Hurricanes

Radiocommunications towers are vulnerable to being damaged during a hurricane. To counteract the wind load on a tower during a hurricane, the tower is constructed in a way that it can support itself and the mounted equipment, using stress-tested materials based on case-by-case specifications and, depending on the height and type of tower, supporting apparatus such as guyed wires. Throughout North America, tower construction companies have adopted the Telecommunications Industry Association (TIA) standard: ANSI/TIA 222, Structural Standard for Antenna Supporting Structures and Antennas. The specifications outlined in the ANSI/TIA 222 standard relate, but are not limited, to tower foundation, types of material, tower design, guying and anchorage, and account for the different categories of hurricane exposure.

Strong winds may cause tree branches to break and come into contact with guyed wires, causing damage to guyed structures that support towers. To prevent this from happening, trees close to a radiocommunications site should be trimmed, particularly with regard to the cutting of rotten branches. Forested areas around tower sites may belong to a private owner, making it difficult for tower owners or operators to trim surrounding vegetation. In such cases, it is recommended that tree branches hanging over the perimeter and into the site be trimmed. To mitigate the effects of hurricanes on towers, mounted antennas and guyed structures, the following standards are applied.

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Mandatory Standards to Mitigate the Effects of Hurricanes on Radiocommunications Towers and Antennas:

(18) Radiocommunications towers shall be constructed in compliance with the ANSI/TIA 222 Structural Standard for Antenna Supporting Structures and Antennas (Telecommunications Industry Association 2005 or relevant subsequent updates).

(19) Guyed assemblies and anchors used to support radiocommunications towers shall comply with the ANSI/TIA 222 Structural Standard for Antenna Supporting Structures and Antennas (Telecommunications Industry Association 2005 or relevant subsequent updates).

Mandatory Standards to Mitigate the Effects of Hurricanes on Radiocommunications Towers and Antennas (cont.):

(20) Mounting of antennas on radiocommunications towers shall comply with the ANSI/TIA 222 Structural Standard for Antenna Supporting Structures and Antennas (Telecommunications Industry Association 2005 or relevant subsequent updates).

(21) Tree branches that hang over the perimeter of a radiocommunications site shall be trimmed.

Note that for all planned radiocommunications tower builds, planning permission must be granted by the Town and Country Planning Division (TCPD) and approval may be required from the Ministry of Works and Transport (MOWT) and the relevant municipal/regional corporation and, for towers in Tobago, the Tobago House of Assembly.

3.2.2.3 Earthquakes

Radiocommunications towers are vulnerable to earthquakes and, as recently as August 2018, Trinidad and Tobago experienced an earthquake with a magnitude of 6.9 at its source. To counteract the effect of earthquakes, towers must be constructed to support themselves and mounted equipment, using case-by-case stress tested materials according to specifications, such as structure class and tower height. Tower construction companies have adopted the Telecommunications Industry Association (TIA) standard: ANSI/TIA 222, Structural Standard for Antenna Supporting Structures and Antennas. To mitigate the effects of earthquakes on radiocommunications towers and mounted antennas, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Earthquakes on Radiocommunications Towers and Antennas:

(22) Radiocommunications towers shall be constructed in compliance with the ANSI/TIA 222 Structural Standard for Antenna Supporting Structures and Antennas (Telecommunications Industry Association 2005 or relevant subsequent updates).

(23) Guyed assemblies and anchors used to support radiocommunications towers shall comply with the ANSI/TIA 222 Structural Standard for Antenna Supporting Structures and Antennas (Telecommunications Industry Association 2005 or relevant subsequent updates).

Mandatory Standards to Mitigate the Effects of Earthquakes on Radiocommunications Towers and Antennas (cont.):

(24) Mounting of antennas on radiocommunications towers shall comply with the ANSI/TIA 222 Structural Standard for Antenna Supporting Structures and Antennas (Telecommunications Industry Association 2005 or relevant subsequent updates).

3.2.3 Technical Standards for Transport Networks

3.2.3.1 Hurricanes

Transport networks including broadcasting STLs may utilise either a wired or wireless medium, both of which are at risk during hurricanes. To mitigate the effects of hurricanes on towers and mounted microwave/point-to-point equipment employed in wireless transport networks and STLs, the standards stated in section 3.2.2.2 of this document shall be applied. To mitigate the effects of hurricanes on aerial fibre optics used in wired transport networks and STLs, the technical standards stated in section 3.1.1.1 of the *Technical Standards for Public Fixed Telecommunications Networks* (TATT 2020 or relevant subsequent updates), along with the following technical standard, shall be applied.

Discretionary Standard to Mitigate the Effects of Hurricanes on Wired Transport Networks:

(4) As far as practicable, telecommunications cables routed through areas with heavily vegetated and sloped lands should be buried in underground ducts.

3.2.3.2 Earthquakes

Transport networks and broadcasting STLs are vulnerable to earthquakes. To mitigate the effects of earthquakes on towers and mounted radiocommunications equipment employed within a wireless transport network or an STL, the standards stated in section 3.2.2.3 of this document shall be applied. For wired transport networks and STLs using underground ducts, the technical standards stated in section 3.1.4.3 of the *Technical Standards for Public Fixed Telecommunications Networks* (TATT 2020 or relevant subsequent updates) shall be applied.

3.2.3.3 Mud Volcanoes

A heavy flow of mud from a volcano could flood nearby roads, impacting parts of the telecommunications infrastructure such as manholes. Mud can enter a manhole through covers that are not watertight, causing damage to underground ducts and cables that are part of a wired transport network. To mitigate the effects of mud volcanoes on wired transport networks, the following standards are applied.

Mandatory Standard to Mitigate the Effects of Mud Volcanoes on Wired Transport Networks:

(25) In areas that are prone to mud volcanoes, telecommunications manhole covers shall be watertight.

Discretionary Standard to Mitigate the Effects of Mud Volcanoes on Wired Transport Networks:

(5) As far as practicable, pole routes that support telecommunications aerial cables should not be run in the proximity of mud volcanoes.

3.3 Technical Standards to Mitigate the Effects of Man-Made Disasters

3.3.1 Technical Standards for Public Mobile Access Networks

An unplanned increase in the use of public mobile access networks by users, especially on a large scale, can cause traffic congestion. To mitigate the effects of such congestion on the networks, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Network Traffic Congestion on Public Mobile Access Networks:

(26) Public mobile access networks shall have the capability to prioritise voice calls to emergency services over normal voice calls. The telephone numbers which shall be prioritised include 990 (fire service), 999 (police service), 811 (ambulance service), and 911 and 112 (transferred to 999 for foreign travellers).

Mandatory Standards to Mitigate the Effects of Network Traffic Congestion on Public Mobile Access Networks (cont.):

(27) Public mobile access networks shall have the capability to prioritise emergency voice, video or data traffic above ordinary traffic (ITU, Y.1271 2014 or relevant subsequent updates).

3.3.2 Technical Standards for Transport Networks

3.3.2.1 Network Congestion

Like access networks, radio frequency (RF) transport networks may also become congested. To mitigate the effects of traffic congestion on mobile RF transport networks, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Network Traffic Congestion on RF Transport Networks:

(28) Public RF transport networks shall be engineered to handle an RF traffic channel utilisation of at least 85% of an RBS site (ITU, E.811 2017 or relevant subsequent updates).

(29) Public RF transport networks shall have the capability to prioritise emergency voice, video or data traffic above ordinary traffic.

3.3.2.2 Destruction of Underground Ducts and Cables by Unauthorised or Unplanned Excavation

Underground ducts and cables used in a transport network or an STL may become damaged due to unauthorised or unplanned excavations. To prevent such damage, the standards in section 3.2.1 of the *Technical Standards for Public Fixed Telecommunications Networks* (TATT 2020 or relevant subsequent updates) are applied.

3.3.2.3 Destruction by Vehicles

Aerial fibre optic cables used in a transport network or an STL may become damaged if they come in contact with high vehicles. To prevent such damage, the standards in section 3.2.2.1 of the *Technical Standards for Public Fixed Telecommunications Networks* (TATT 2020 or relevant subsequent updates) are applied.

3.3.2.4 Unauthorised Burning of Debris

The burning of debris or rubbish on roadsides may result in damage to low-hanging aerial fibre optic cables used in transport networks or STLs. To prevent such damage, the standards in section 3.2.2.2 of the *Technical Standards for Public Fixed Telecommunications Networks* (TATT 2020 or relevant subsequent updates) are applied.

3.3.2.5 Tree Pruning

The trimming of trees hanging over aerial telecommunications cables used in transport networks or STLs may result in damage to the cables from falling branches. To prevent such damage, the standards in section 3.2.2.3 of the *Technical Standards for Public Fixed Telecommunications Networks* (TATT 2020 or relevant subsequent updates) are applied.

3.3.3 Technical Standards for Public Mobile Core Networks

All network elements within the ecosystem may become congested and, like access and transport networks, core networks can also become congested due to the unexpected overutilisation of a network on a large scale. To mitigate the effects of traffic congestion on a mobile core network, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Network Traffic Congestion on Public Mobile Core Networks:

(30) Public mobile core networks with 1+1 redundancy levels shall be engineered for a maximum peak packet data traffic utilisation of 40%. Public mobile core networks with N+X (X is equal to multiples of 1) redundancy levels shall be engineered for a maximum peak packet data traffic utilisation of 85% (ITU, E.811 2017 or relevant subsequent updates).

(31) Public mobile core networks shall be engineered to ensure service availability of 99.999%.

3.3.4 Technical Standards for Radiocommunications Towers and Antennas

In accordance with the Trinidad and Tobago Civil Aviation [(No.12) Aerodrome Licensing] Regulations, the Trinidad and Tobago Civil Aviation Authority (TTCAA) has adopted the International Civil Aviation Organization (ICAO) Annex 14 to the Convention on International Civil Aviation International Standards and Recommended Practices for the design of aerodromes (airports and heliports). A determination will be made by TTCAA regarding the construction of any obstacle (including towers) within these defined radii, within which these obstacle limitation surfaces lie. For towers that are located outside of the defined radii and are 110 metres or more in height, TTCAA requires notification of their construction (TTCAR No.12).

In addition to tower height restrictions, the ICAO Annex 14 states the illumination and marking specifications that towers shall comply with. To reduce the chance of aircraft colliding with radiocommunications towers, the following standards are applied.

Mandatory Standards to Reduce the Chance of Aircraft Colliding with Radiocommunications Towers:

(32) The defined obstacle limitation surfaces will determine the height of the proposed radiocommunications towers in the vicinity of the aerodrome, in accordance with Annex 14 Volume I and Volume II. The radii and the volumes of the ICAO Annex 14 relevant to the types of aerodromes are as follows:

a) The height of radiocommunications towers located within a radius of 15 kilometres from an airport (ICAO 2018 or relevant subsequent updates) *shall comply with the specifications stated in chapter 4 of ICAO Annex 14, volume 1.*

b) The height of radiocommunications towers located within a radius of 3.386 kilometres from a heliport/helideck (ICAO 2020 or relevant subsequent updates) *shall comply with the specifications stated in chapter 4 of ICAO Annex 14, volume 2.*

(33) Radiocommunications towers shall comply with the finishing and marking specifications stated in chapter 6 ICAO Annex 14, volume 1.

Note: These standards do not apply to structures located on offshore facilities on which communications equipment or antennas are mounted.

3.3.5 Technical Standards for Structures Used to House Communications Equipment

Buildings and outdoor cabinets used to house communications equipment should be constructed to withstand the effects of man-made disasters such as power outages, fires, burglary and sabotage. To mitigate these effects, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Man-Made Disasters on Structures Used to House Communications Equipment Operated by Concessionaires or Licensees:

(34) Buildings that house active communications equipment shall be equipped with standby power facilities.

(35) Standby power facilities shall have the following features:

a) Automatic load transfer

b) Capability of supporting full equipment and building ancillary service loads for a period of two days without refuelling for key urban sites, and one week for key rural sites. Note that the word "key" is used in the sense that key sites support other sites in the network.

(36) Buildings that house communications equipment shall be adequately secured.

(37) Buildings that house communications equipment shall be equipped with fire and smoke detectors (manual and automatic).

(38) Outdoor cabinets used to house RBS equipment shall be wired to accommodate standby power. Such standby power shall also be able to fully support equipment and building ancillary service loads and charge standby power batteries.

(39) Outdoor cabinets that house active electronics but do not have standby power generators shall have standby power batteries, fuel cell technology or solar panels capable of supporting full equipment load for a minimum period of six hours.

Mandatory Standards to Mitigate the Effects of Man-Made Disasters on Structures Used to House Communications Equipment Operated by Concessionaires or Licensees (cont.):

(40) Outdoor cabinets used to house communications equipment shall be properly secured.

(41) Controlled sites in which outdoor cabinets used to house communications equipment are located shall be secured with fences, locked gates and other security measures.

Note: During power outages that last longer than the run time of standby power supply systems, relevant standby generators are to be refuelled and mobile generators are to be deployed at critical sites that operate with standby batteries only.

3.3.6 Technical Standards for Radiocommunications Equipment Located in Industrial Environments

Sometimes an industrial incident or accident may damage communications equipment located either within the premises of the industry or in proximity to the premises, including offshore rigs, refineries and manufacturing plants. Depending on the type of industry, accidents may include spillage, explosions, fires or structural collapse, like the explosion at NiQuan Energy's gas-to-liquids (GLT) plant, which occurred on 7th April 2021. To mitigate the damage caused by these industrial incidents or accidents, communications equipment and supporting racks/cabinets located near or within an industrial environment are to be designed to withstand the effects of such hazardous events. To mitigate such effects, the following standard is applied.

Mandatory Standard to Mitigate the Effects of Incidents/Accidents on Radiocommunications Equipment Located in Industrial Environments:

(42) Radiocommunications equipment located in industrial spaces that are classified as Class 1, Division 1 or Division 2 locations, or Zone 0, Zone 1 or Zone 2 environments, shall comply with, but not be limited to, relevant National Fire Protection Association (NFPA), International Organization for Standardization (ISO) and Occupational Safety and Health Administration (OSHA) standards that mitigate the effects of hazards present within these types of locations or environments.

4 Redundancy in Transport Networks of Public Mobile Telecommunications and Broadband Wireless Access Networks

The most resilient transport network for cellular mobile and BWA network base stations that can be implemented is via redundant underground ducted fibre links, which require adequate road reserve. To minimise the risk of a redundant transport network which utilises underground ducts becoming inoperable during an earthquake, the technical standards stated in section 3.1.4.3 of the *Technical Standards for Public Fixed Telecommunications Networks* (TATT 2020 or relevant subsequent updates) shall be applied.

The installation of underground ducted fibre cables as a redundant transport network to connect all rural base stations is expensive and, depending on factors such as topography and availability of adequate access roads, less costly systems such as aerial fibre optic and point-to-point links are often utilised in rural, thinly populated areas. Microwave/point-to-point systems may not be able to provide full redundancy to a fibre link and, as a result, only critical services are to be facilitated when using a microwave/point-to-point redundancy link. In urban areas with higher population density, the distance between cellular mobile sites and switches may be shorter and, therefore, ducted fibre transport networks are often implemented. However, factors such as TCPD restrictions and approvals, as well as cost, may make the burying of underground ducts throughout an urban area impracticable.

Ring topology is commonly employed in optical transport networks (OTNs) to provide redundancy. 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, G.873.1 2014 or relevant subsequent updates) .

To establish redundancy within mobile telecommunications and BWA transport networks, the standards in section 5.1 of the *Technical Standards for Public Fixed Telecommunications Networks* (TATT 2020 or relevant subsequent updates), along with the following standards, are applied.

Mandatory Standards to Establish Redundancy in Transport Networks of Public Mobile Telecommunications and Broadband Wireless Access Networks:

(43) Spare equipment for microwave links used in transport networks shall be readily available.

(44) Spare equipment for microwave links used in transport networks shall be stored in a secure facility.

Discretionary Standards to Establish Redundancy in Transport Networks of Public Mobile Telecommunications and Broadband Wireless Access Networks:

(6) In urban areas, wired transport network ring topologies should be implemented using underground ducts and cables.

(7) In rural areas, transport network ring topologies should be implemented using aerial cables or point-to-point links.

5 Redundancy in Broadcasting Systems

5.1 Studio-to-Transmitter Links (STLs)

STL equipment is susceptible to damage during hurricanes, so a level of redundancy should be established. As with transport networks, redundancy in STLs that operate over long distances, with the transmitter located in a remote rural area, is generally introduced through the installation of spare point-to-point radiocommunications equipment, to avoid the high cost of running aerial or underground cables from the studio to the transmitter site. For STLs that operate within urban areas, underground ducts or aerial cables are often more feasible to use as a redundant link. To establish redundancy in broadcasting STLs, the following standards are applied.

Mandatory Standards to Establish Redundancy in STLs:

(45) Redundant transport networks in STLs shall be deployed as follows:

a) For transmitter sites located outside the same urban area as the broadcasting studio, a standby point-to-point STL or spare equipment shall be utilised.

b) For transmitter sites located within the same urban area as the broadcasting studio, a redundant fibre optic STL, standby point-to-point STL, or spare equipment shall be utilised.

(46) Spare STL equipment shall be kept securely at the relevant sites.

(47) Adequate technical resources shall be available to restore an STL within a reasonable timeframe, in accordance with due diligence and the prevailing circumstances.

5.2 Transmitters

Broadcasting transmitter sites are susceptible to damage during hurricanes and, therefore, a standby or a redundant broadcasting system is required for resilience. During or immediately after a hurricane, road access to a broadcasting transmitter site may be impassable, making it difficult to repair transmitter equipment. Until the primary transmitter site becomes accessible, standby transmitter equipment in the form of a low-powered exciter and broadcasting transmitter, along

with an antenna, can be deployed and operated from the studio or, if possible, at a location higher than the studio building. Although the power being broadcast by the standby equipment would not provide the same coverage as the primary transmitter, such standby power will provide coverage to a reasonable area. To implement redundancy within broadcasting transmitters, the following standards are applied.

Mandatory Standards to Establish Redundancy in Transmitter Sites:

(48) A low-powered transmitter shall be stored at the broadcasting studio as follows:

a) The output power from the radio transmitter shall be, at a minimum, 100 watts.

b) The output power from the television transmitter shall be, at a minimum, 300 watts.

(49) Suitable antennas that are designed to provide the required coverage from the secondary transmitter, in accordance with concessionaire's obligations, shall be stored at the broadcasting studio.

(50) Adequate technical resources shall be available to power up and operate the backup low-powered transmitter within a reasonable timeframe in accordance with due diligence and the prevailing circumstances.

(51) A secondary broadcasting site, for example the broadcasting studio, shall be used if the primary transmitter site is inoperative and inaccessible.

(52) Spare broadcasting equipment shall be securely stored in the relevant facility.

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