Telecommunications Authority of Trinidad and Tobago

Consultative Document

on

Technical Standards for Wireless Networks

(First round)

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List of Abbreviations

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

1. Introduction

1.1 Rationale

The Telecommunications Authority of Trinidad and Tobago (the Authority) considers it imperative to develop technical standards to mitigate the effects of natural and man-made disasters on wireless telecommunications networks within Trinidad and Tobago. The development of these technical standards is critical in light of the damage caused by natural disasters throughout the Caribbean, such as the impact of Hurricane Irma on the telecommunications infrastructure of Barbuda and Puerto Rico in 2017, and the destruction caused by Hurricane Maria to the telecommunications infrastructure of Dominica in 2018.

Wireless networks are comprised of facilities that are susceptible to natural and man-made disasters. It is vital that these facilities, through the implementation of appropriate technical standards, be sufficiently resilient to withstand such disasters, to secure critical personal and emergency communication. By enhancing the resilience of facilities within a wireless network, the level of damage, as well as the disruption of services, during and following disasters would be minimal. Wireless networks that exist in Trinidad and Tobago relate to cellular mobile networks, free-to-air (FTA) broadcast stations, broadband wireless access (BWA) networks, land mobile radiocommunications systems and point-to-point radiocommunications systems.

One of the responsibilities of the Authority is to identify, adopt or establish technical standards.

1.2 Purpose

This document, *Technical Standards for Wireless Networks*, establishes technical standards to enhance the robustness of wireless networks in Trinidad and Tobago, in relation to:

i. making equipment and facilities within wireless networks against natural and man-made disasters.

ii. implementing redundancy for key areas within wireless networks.

1.3 Background

In 2019, the Authority, in collaboration with public fixed telecommunications operators through a technical working group (TWG), developed the document *Technical Standards for Public Fixed Telecommunications Networks*, in which technical standards (mandatory and discretionary) were established to mitigate the effects of natural and man-made disasters on public fixed telecommunications networks.

Like public fixed telecommunications networks, wireless networks consist of common facilities which are also vulnerable during disasters. Facilities such as cellular sites comprise outdoor radio cabinets or buildings used to house telecommunications equipment, and towers (or poles) including mounted antennas, cables and cable accessories. In a cellular site, the active electronic equipment can be installed along with the antennas on the pole or tower. A cellular site is vulnerable during natural disasters such as lightning strikes, earthquakes, bush fires, hurricanes and floods, and man-made disasters, such as power outages and malicious damage to infrastructure or equipment. The tower and mounted antennas are also vulnerable to man-made disasters such as collisions involving aircraft. The impact caused by damage to a cellular site due to a disaster will be a disruption in service locally, nationwide, or internationally.

Broadcast 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 the tower. The effect of damage to a broadcast site will be a disruption in service.

Studio transmitter links (STLs) generally use point-to-point radiocommunications, although fixed line STLs do exist, 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. Fibre optic links, particularly aerial cable routes, are at risk from natural disasters, such as lightning strikes, earthquakes, hurricanes and bushfires. They are also susceptible to man-made disasters, such as aerial cable breakage due to goods or construction vehicles. Damage to an STL or transport network would result in a disruption in service.

Radiocommunications equipment located and operated within industrial environments is at risk from industrial accidents or events. Such equipment may belong to public telecommunications operators or private network operators and, therefore, any damage may lead to disruption of a public service or the operation of a company.

To mitigate the effects of natural and man-made disasters on key components of wireless networks, such networks should conform to appropriate technical standards. Additionally, the appropriate technical standards should apply to the various types of wireless networks.

1.4 Objectives

This document:

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

b) establishes technical standards:

i. to enable wireless network equipment and facilities to withstand these detrimental effects.
ii. to enhance redundancy for key areas within wireless networks.

1.5 Scope

This document does not deal with cybersecurity as a man-made disaster nor provide standards to mitigate the effects of cybersecurity on wireless networks.

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

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

1.7 Review Cycle

This standards document will be revised periodically to meet changing and unforeseen circumstances. The Authority will review the document 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 standards document may be directed to the Authority via email at info@tatt.org.tt.

1.8 Consultation Process

In accordance with its *Procedures for Consultation in the Telecommunications Sector of Trinidad and Tobago (version 2.0, 2010)*, the Authority will seek the views of the general public and other stakeholders regarding this document. 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.

1.9 Other Relevant Documents

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

a) The Telecommunications Act, Chap. 47:31

b) The *Authorisation Framework for the Telecommunications and Broadcasting Sectors of Trinidad and Tobago* (in effect)

1.10 Definitions

Class 1 location: Class 1 locations are those in which flammable gases or vapours are or may be present in the air, in quantities sufficient to produce explosive or ignitable mixtures. Class I locations include Division 1 and Division 2 locations (United States Department of Labour n.d.)

Class 1, Division 1 location: A Class 1, Division 1 location is one in which:

a) ignitable concentrations of flammable gases or vapours may exist under normal operating conditions or may exist frequently due to repair or maintenance operations or leakage (United States Department of Labour n.d.)

b) the breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapours and might also cause simultaneous failure of electric equipment (United States Department of Labour n.d.)

Class 1, Division 2 location: A Class 1, Division 2 location is one:

a) in which volatile flammable liquids or flammable gases are handled, processed or used, but in which these hazardous liquids, vapours or gases will normally be confined within closed containers or closed systems from which they can escape only in the case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment (United States Department of Labour n.d.)

b) in which ignitable concentrations of gases or vapours are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment (United States Department of Labour n.d.)

c) that is adjacent to a Class 1, Division 1 location, and to which ignitable concentrations of gases or vapours might occasionally be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided (United States Department of Labour n.d.)

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)

Lightning protection system (LPS): A complete system used to reduce physical damage due to lightning flashes to a structure (ITU, K.112 - Lightning protection, earthing and bonding: Practical procedures for radio base stations 2019)

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.

Radio base station (RBS): An installation intended to provide access to the telecommunications system by means of radio waves (ITU, K.56 - Protection of radio base stations against lightning discharges 2010)

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)

Zone 0 location: An area in which an explosive gas atmosphere is present continuously or for long periods (UK Health and Safety Executive 2004)

Zone 1 location: An area in which an explosive gas atmosphere is likely to occur in normal operation (UK Health and Safety Executive 2004)

1.11 Compliance Notation

The technical standards stated in this document are classified as either mandatory or discretionary, 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 this regard, 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

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

i. **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, especially to telecommunications infrastructures.

ii. **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, Hazards - Earthquakes 2013). The strength of an earthquake is indicated by the 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. But due to the short duration, the long distance from the epicentre and/or the depth from which the earthquakes originated, the effects have not been severe.

iii. **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 exacerbated this problem. Many parts of the country are prone to flooding, including the capital city, Port of Spain.

iv. **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. The country, however, does experience tropical storms which cause minimal damage to very few structures.

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 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.

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 in the rainy season.

vii. **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. Generally, the volume of mud that is spewed from a mud volcano is minimal. However, in 1997, the Piparo mud volcano aggressively erupted, resulting in houses, cars and roads being covered in mud. The damage to the houses caused 31 families to be displaced from their homes.

viii. **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 wireless communications networks are identified below:

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

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

iii. **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 elevated loads, for example, containers, cement or music trucks and land-drilling rigs. The cables are, therefore, susceptible to being damaged.

iv. **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.

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

vi. **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

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

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

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

x. **Unauthorised burning of debris:** Flames caused by 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 of equipment and facilities that are susceptible to natural and man-made disasters. Such facilities include:

(a) Structures that house communications equipment
(b) Radiocommunications towers
(c) Wireless access networks
(d) Core networks
(e) Transport networks
(f) Radiocommunications equipment located in industrial environments
(g) Broadcast transmitters including STLs

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 Structures that House Communications Equipment

3.2.1.1 Lightning Strikes

3.2.1.1.1 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 shall be connected to 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 shall be 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 shall be grounded and bonded to the building ground ring using grounding conductors. The building ground ring shall be connected at a minimum of 2 points to the grounding ring of the tower.

To increase the resistivity of the upper soil around the structure or site that houses communications equipment, thus reducing harm to persons from voltage gradients within the soil, a layer of crushed stone should be placed around the perimeter of the site or building (ITU, K.56 - Protection of radio base stations against lightning discharges 2010). To mitigate the effects of lightning strikes on structures that house communications equipment, the following standards are applied.

Mandatory Standard to Mitigate the Effects of Lightning Strikes on Structures that House Communications Equipment:

(1) Earthing systems installed in buildings that house communications equipment shall comply with, at a minimum or better, the External and Internal Grounding (Earthing) standards for buildings in chapters 4 and 5 of the Motorola R56 document, Standards and Guidelines for Communication Sites.

Discretionary Standards to Mitigate the Effects of Lightning Strikes on Structures that House Communications Equipment:

(1) A layer of crushed stone should be placed around the perimeter of the structure that houses communications equipment (ITU, K.56 - Protection of radio base stations against lightning discharges 2010).
(2) The layer of crushed stone should be placed at least one metre away from the fence.

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 which is located either on the roof or in an equipment room located 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 should be done via a minimum of 2 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 should have 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 shall also be 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) Earthing systems employed to protect a rooftop RBS from lightning strikes shall comply with, at a minimum or better, the External Grounding (Earthing) standards for rooftop tower and equipment in chapter 4 of the Motorola R56 document, Standards and Guidelines for Communication Sites.

(3) The top of the lightning rod installed on the antenna mast shall be, at a minimum, 30 centimetres above the antennas of the rooftop RBS (ITU, K.112 - Lightning protection, earthing and bonding: Practical procedures for radio base stations 2019).

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, fire breaks should be constructed, where practicable, around the perimeter of the 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 should 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:

(4) Outdoor cabinets used to house communications equipment shall be constructed with fireproof material.

(5) The vegetation and grass that surround the site that houses communications equipment shall be trimmed and kept low.

(6) 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:

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

(4) The width of the fire break should be a minimum of 10 metres.

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, at a minimum, Category 4 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:

(7) Buildings that house communications equipment shall comply with internationally recognised building codes adopted in Trinidad and Tobago.

(8) Outdoor cabinets that house communications equipment shall be able to withstand hurricanes up to Category 4.

(9) Outdoor cabinets that house RBS electronic communications equipment shall have protection against dust and resistance against jets of water at a minimum, in accordance with international protection (IP) 55 of the specification IEC 60529 (ITU, L.70. Managing active electronics in the outside plant 2007).

3.2.1.4 Earthquakes

Buildings and outdoor cabinets that house communications equipment need to be constructed to withstand the effects of earthquakes up to a magnitude of 7 on the Richter scale. 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:

(10) Buildings that house communications equipment shall comply with internationally recognised building codes adopted in Trinidad and Tobago.

(11) Outdoor cabinets that house communications equipment shall be able to withstand, at a minimum, earthquakes of a magnitude of 7 on the Richter scale.

(12) 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. Managing active electronics in the outside plant 2007).

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. To mitigate those effects, the following standards are applied.

Mandatory Standards to Mitigate the Effects of Floods on Structures that House Communications Equipment:

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

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

(15) 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 Standards to Mitigate the Effects of Mud Volcanoes on Structures Used to House Communications Equipment:

(16) As far as practicable, structures that are used to house communications equipment shall not be located within close proximity of a mud volcano.

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

3.2.2 Technical Standards for Radiocommunications Towers

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 should be 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 should be 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, the following standards are applied.

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

(18) Radiocommunications towers/poles shall be grounded in compliance with, at a minimum or better, the External Grounding (Earthing) standards for towers in chapter 4 of the Motorola R56 document: Standards and Guidelines for Communication Sites.

(19) The top of the lightning rod installed on the antenna mast shall be, at a minimum, 30 centimetres above the antennas of the rooftop RBS (ITU, K.112 - Lightning protection, earthing and bonding: Practical procedures for radio base stations 2019).

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 upon 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. Towers located throughout Trinidad and Trinidad should be constructed to withstand, at a minimum, the effects of a Category 4 hurricane.

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 that hang over the perimeter and into the site be trimmed. To mitigate the effects of hurricanes on towers and guyed structures, the following standards are applied.

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

(20) Radiocommunications towers shall be constructed in compliance with the ANSI/TIA 222 standard.
(21) Radiocommunications towers shall withstand hurricanes up to Category 4.
(22) Guyed assemblies and anchors used to support radiocommunications towers shall comply with the ANSI/TIA 222 standard.
(23) Mounting of antennas on radiocommunications towers shall comply with the ANSI/TIA 222 standard.
(24) Trees that are in close proximity of a radiocommunication tower shall be kept trimmed if practicable, or trees overhanging into the perimeter of a radiocommunication site shall be kept trimmed.

3.2.2.3 Earthquakes

Radiocommunications towers are vulnerable to earthquakes and, as recent 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, the following standards are applied.

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

(25) Radiocommunications towers shall be constructed in compliance with the ANSI/TIA 222 standard.
(26) Radiocommunications towers shall withstand earthquakes up to a magnitude of 7 on the Richter scale.
(27) Guyed assemblies and anchors used to support radiocommunications towers shall comply with the ANSI/TIA 222 standard.
(28) Mounting of antennas on radiocommunications towers shall comply with the ANSI/TIA 222 standard.

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 Authority's document *Technical Standards for Public Fixed Telecommunications Networks (in effect)* shall be applied.

3.2.3.2 Earthquakes

Transport networks and broadcasting STLs are vulnerable in 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 Authority's document *Technical Standards for Public Fixed Telecommunications Networks (in effect*) shall be applied.

3.2.3.3 Mud Volcanoes

A heavy flow of mud from a volcano would flood nearby roads, impacting parts of the telecommunications infrastructure such as manholes. Mud may 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 Standards to Mitigate the Effects of Mud Volcanoes on Wired Transport Networks:

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

(30) If practicable, pole routes that support telecommunications aerial cables shall 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

During and in the aftermath of natural or man-made disasters, access networks in mobile network infrastructure may become congested due to the overload of calls and the increased volume of data on the network. To mitigate the effects of traffic congestion on public mobile telephone access networks, the following standards are applied.

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

(31) Public mobile access networks shall have the functionality to prioritise voice calls to emergency services over normal voice calls.

(32) Public mobile access networks shall have the functionality to prioritise voice services above Internet access services or data services. Voice services include voice service over IP such as voice over LTE (VoLTE).

3.3.2 Technical Standards for Transport Networks

3.3.2.1 Network Congestion

Like access networks, transport networks within a mobile network infrastructure may become congested during and in the aftermath a natural or man-made disaster. To mitigate the effects of traffic congestion on mobile transport networks, the following standards are applied.

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

(33) Public mobile transport networks shall be engineered to handle a minimum of 120% of the access traffic capacity of an RBS site.

(34) Public mobile transport networks shall have the functionality to prioritise voice services above Internet access services or data services. Voice services include voice service over IP such as voice over LTE (VoLTE).

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 STL may become damaged due to unauthorised or unplanned excavations. To prevent this damage to underground ducts and

cables from happening, the standards in section 3.2.1 of the Authority's document *Technical Standards for Public Fixed Telecommunications Networks* are applied.

3.3.2.3 Destruction by Vehicles

Aerial fibre optic cables used in a transport network or STL may become damaged if they come in contact with high vehicles. To prevent this damage to aerial fibre optic cables from happening, the standards in section 3.2.2.1 of the Authority's document *Technical Standards for Public Fixed Telecommunications Networks* 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 this damage to aerial fibre optic cables from happening, the standards in section 3.2.2.2 of the Authority's document *Technical Standards for Public Fixed Telecommunications Networks* are applied.

3.3.2.5 Tree Pruning

The trimming of tree branches hanging over aerial telecommunications cables may result in aerial cables used in transport networks or STLs being damaged if falling branches hit them. To prevent this damage to aerial fibre optic cables from happening, the standards in section 3.2.2.3 of the Authority's document *Technical Standards for Public Fixed Telecommunications Networks* are applied.

3.3.3 Technical Standards for Public Mobile Core Networks

All network elements within the ecosystem may become congested and, like the access and transport networks, the core network can also become congested during and in the aftermath of a natural or man-made disaster. 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:

(35) Public mobile core networks shall be engineered for a peak traffic utilisation of 40%.

(36) Public mobile core networks shall be engineered with redundancy and high availability of 99.999%.

3.3.4 Technical Standards for Radiocommunications Towers

According to the land use guidelines of the *Planning Policy for Public Mobile Telecommunication Services (2007)* written by the Town and Country Planning Division (TCPD), the construction of telecommunications towers within varying radiuses around an aerodrome is not permitted, with the distances of such radiuses depending on the type of aerodrome, which includes airports, heliports and airstrips. Besides the distance from an aerodrome at which the tower can be constructed, the TCPD's planning policy for public mobile telecommunications services also states the illumination and marking specifications which towers shall comply with. However, there are towers which, based on circumstances, are located within the restricted radiuses around aerodromes and, as a result, such towers must comply with the standards adopted by the Trinidad and Tobago Civil Aviation Authority (TTCAA). The standard adopted by the TTCAA for the deployment of radiocommunications towers that are located in close proximity to aerodromes is the International Civil Aviation Organization (ICAO) Annex 14 Standard: volume 1. The specifications outlined in the ICAO Annex 14, volume 1 standard relate, but are not limited, to tower lighting and tower marking. 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:

(37) Radiocommunications towers shall be constructed in compliance with the following sections of the Planning Policy for Public Mobile Telecommunication Services (in effect) *of the Ministry of Planning and Development, Town and Country Planning Division (TCPD): TTCAA land use requirements, illumination, exterior finishing and markings.*

(38) Towers that are constructed in proximities of aerodromes, with such proximities of aerodromes stated in the TCPD's Planning Policy for Public Mobile Telecommunication Services *document, shall comply with the marking and lighting of radiocommunications towers standards in chapter 6 of* the International Civil Aviation Organization (ICAO) Annex 14 standard, volume 1.

(39) The maximum height of radiocommunications towers located in the proximity of aerodromes shall be 101 feet.

***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:

(40) Buildings that house communications equipment shall be equipped with stand-by power facilities and batteries.

(41) Stand-by 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 core urban sites, and one week for selected important rural sites*

(42) Buildings that house communications equipment shall be secured.

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

(44) Outdoor cabinets used to house RBS equipment shall be wired to accommodate backup power.

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

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

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

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 the NiQuan Energy's gas-to-liquids (GLT) plant, which occurred on April 7, 2021. As a result of 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:

(48) Radiocommunications equipment located in industrial environments that are classified as Class 1, Division 1 or Division 2 locations or Zone 0 or Zone 1 locations shall comply with standards that mitigate the effects of hazards present within these types of locations.

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

The most resilient implementation of a redundant transport network for cellular mobile and BWA network base stations is via underground ducted fibre links, which requires adequate road reserve. To minimise the risk of a redundant transport network which utilises underground ducts becoming inoperable during an earthquake, the technical standards previously stated in section 3.2.3.2. of this document shall be applied.

However, the installation of underground ducted fibre cables as a redundant transport network to connect all rural base stations is expensive and, hence, 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 can be utilised in rural thinly populated areas. Microwave/point-to-point systems may not be able to provide full redundancy and, as a result, only critical services are to be facilitated. In urban areas with higher population density, the distance between cellular mobile sites and switches may be shorter and, therefore, ducted fibre transport networks can be implemented. However, factors such as town and country 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, ITU-T Recommendations- G.873.1. Optical transport network (OTN): Linear protection 2014).

To implement redundancy within mobile telecommunications and BWA transport networks, the standards in section 5.1 of the Authority's document *Technical Standards for Public Fixed Telecommunications Networks*, along with the following standards, are applied.

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

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

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

Discretionary Standards to Implement Redundancy in Mobile Telecommunications Transport Networks:

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

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

5 Redundancy in Broadcast Systems

5.1 Studio Transmitter Links

STL equipment is susceptible to damage during hurricanes and, therefore, a level of redundancy should be implemented in the system. As with transport networks, redundancy in STLs that operate over long distances, with the transmitter located in a remote rural area, could be implemented through the installation of spare point-to-point radiocommunications equipment due to 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 can be used as a redundant link. To implement redundancy within broadcast STLs, the following standards are applied.

Mandatory Standards to Implement Redundancy in STLs:

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

a) For transmitter sites that are located outside of the same urban area as the broadcasting studio, redundant point-to-point STLs shall be utilised.

b) For transmitter sites that are located within the same urban area as the broadcasting studio, redundant fibre optic STLs or point-to-point STLs shall be utilised.

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

(53) Adequate technical resources shall be available to restore an STL within a reasonable timeframe.

5.2 Transmitters

Broadcasting transmitter sites are susceptible to damage during hurricanes and, therefore, a backup or a redundant broadcast system is required. During or immediately after a hurricane, road access to a broadcast transmitter site may be impassable, making it difficult to repair transmitter equipment. Until the transmitter site becomes accessible, backup 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 broadcasted by the backup equipment would not provide the same coverage as the primary transmitter, such backup power will provide coverage to a reasonable size area. To implement redundancy within broadcast transmitters, the following standards are applied.

Mandatory Standards to Implement Redundancy in Transmitter Sites:

(54) 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 (W).

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

(55) Suitable antennas that are designed to provide maximum coverage from the transmitter shall be stored at the broadcast studio.

(56) Adequate technical resources shall be available to power up and operate the backup low-powered transmitter within a reasonable timeframe.

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

(58) Spare broadcasting equipment shall be securely stored in the relative facility.