



**Commission for Caribbean
Communications Resilience**

Strategies for Strengthening Caribbean Communications Resilience

About the Caribbean Telecommunications Union (CTU)

The CTU is an inter-governmental treaty organization which represents the interests of member-state governments, telecommunications regulators, service providers and end-users in the Caribbean region.

In addition to its routine statutory meetings, the CTU convenes events such as the Caribbean ICT Roadshow, Caribbean Internet Governance Forum and ICT Ministerial Briefing Seminars, and facilitates the mobilization of its diverse stakeholder base in support of the development and strengthening of the Caribbean's telecommunications sector and Internet economy.



About the Commission on Caribbean Communications Resilience (CCCR)

The CCCR was formed in 2017 to recommend strategies for Caribbean governments to improve the resilience of the region's communications infrastructure in the face of natural disasters.

The Commission comprises subject matter experts from technical, policy and academic bodies, as well as representatives from the Internet and telecommunications industry.



Table of Contents

Acknowledgements	5
Glossary	6
1 Executive Summary	7
2 Why Resilient Caribbean Communications Infrastructure Matters.....	11
3 Problem Statement	12
3.1 The Caribbean Telecommunications Union's Response	12
3.2 Commission Mandate	12
3.3 Commission Structure.....	12
3.4 Commission Output	13
3.5 CCCR Guiding Principles	13
4 CCCR Study.....	15
4.1 CCCR Scope	15
4.2 Methodology.....	15
4.3 Findings, Assessment and Recommendations	16
5 Public Policy Assessment and Recommendations	17
5.1 Policy Scorecard	17
5.2 Public Policy Strategy.....	18
5.3 Policy Recommendations	19
6 Regulatory Assessment and Recommendations	31
6.1 Regulatory Scorecard.....	31
6.2 Regulatory Strategies.....	32
6.3 Starter Activities.....	36
7 Findings of Secondary Research.....	37
7.1 Body of Knowledge.....	37
7.2 Documented findings from 2017 hurricanes	38

8	<i>Roadmap for Building Communications Resilience</i>	40
8.1	Very Early Activities	40
8.1.1	Funding for Fostering Resilience	40
8.1.2	Buildings and communication Installation codes	40
8.1.3	General Provisions	41
8.1.4	Obligations for Public Broadcasters	41
8.1.5	Obligations for Network Operators	42
8.1.6	Cultivate a new generation of HAM Operators	42
8.2	Early Activities	43
8.2.1	Information Requirements	43
8.2.2	Preparatory Planning Considerations (General)	43
8.2.1	Preparatory Planning Considerations (Human resources)	44
8.2.2	Agreements	44
8.2.3	The Plans	44
8.3	Pre Disaster Activities	45
8.4	Disaster Circumstances	45
8.5	Post Disaster	46
9	<i>Discussion and Conclusion</i>	47
	<i>Appendix I: Guiding Principles for CCCR's Analysis</i>	48
	<i>APPENDIX II: Network Resilience Questionnaire for Policy Makers</i>	51
	<i>APPENDIX III: Background Information Sought from Regulators</i>	54

Acknowledgements

The Caribbean Telecommunications Union gratefully acknowledges the contribution of the following organisations and individuals without whose cooperation, the compilation of this report would not have been possible.

- Commissioners of the Commission on Caribbean Communications Resilience (CCCR)
- American Registry for Internet Numbers (ARIN)
- Caribbean Network Operators Group (CaribNOG)
- Caribbean Telecommunications Union (CTU) Secretariat
- Covela Foundation
- Eastern Caribbean Telecommunications Authority (ECTEL)
- Organization of Eastern Caribbean (OECS) Commission
- Packet Clearing House (PCH)
- The many key Caribbean informants, who provided critical inputs through surveys and interviews, including but not limited to:
 - Policy makers
 - Telecommunications regulators
 - Amateur radio operators
 - Broadcasters
- Commercial operators
- The University of the West Indies (UWI), St Augustine
- U.S. Federal Communications Commission (FCC)

Glossary

CARICOM	Caribbean Community
CCCR	Commission on Caribbean Communications Resilience
CDEMA	Caribbean Disaster and Emergency management Agency
CTU	Caribbean Telecommunications Union
DMA	Disaster Management Agency
DR	Disaster Relief
DRM	Disaster Risk Management
DRP	Disaster Recovery Plan or Planning
EOC	Emergency Operating Centre
GIS	Geographical Information System
HAM	Amateur Radio
NECP	National Emergency Communication Plan
NTRC	National Telecommunications Regulatory Commission
PP	Public Protection
PPDR	Public Protection and Disaster Relief
RNAT	Rapid Needs Assessment Team
TVWS	Television White Space

1 Executive Summary

Communications is an essential element of disaster response and management. Without the ability to communicate, it would be impossible to mount effective mitigation and relief programmes. The 2017 Atlantic hurricane season, a manifestation of the changing climate, highlighted the importance of having reliable communications, when 10 Caribbean countries were adversely affected by significant storms and hurricanes resulting in the loss of communication services for extended periods.

In the aftermath of the 2017 hurricane season, the Caribbean Telecommunications Union (CTU) established a Commission on Caribbean Communications Resilience, (CCCR) with a view to understanding nature of the communication failures and making recommendations for strengthening the policy and regulatory environment in order to improve the resilience of the region's communications capability.

The work of the CCCR was executed primarily via video-conference, teleconference, email and in-country interviews. Information was collected via several data gathering channels which included survey instruments produced by the CCCR; interviews with service providers, policy makers and regulators; desk research and discussion with practitioners drawn from national, regional and international organisations in the communications industry. The information gathered was analysed and used to inform the CCCR's recommendations

Findings

The CCCR noted that building communications resilience requires investment but there are few funds and financial incentives that support network operators in building greater network resilience. Universal Service Funds, where they exist, generally do not provide for resilience.

Minimum standards for buildings housing critical communications infrastructure and network installations must be specified and adhered to by all operators. To the extent practicable infrastructure sharing should be mandated as only 2 of 6 surveyed countries have regulations that mandate facilities sharing.

Minimum standards must also be established for service delivery to different classes of stakeholders to ensure that communication services are available throughout the disaster or soon thereafter. Disaster management agencies must be able to communicate with all citizens. Network coverage with appropriate communications channels must be ubiquitous..

Timely information is critical for a successful disaster response management, therefore it is imperative that comprehensive databases including critical communication infrastructure installations and emergency resources are maintained and available for sharing for emergency purposes.

Provisions must be made to ensure that responders are mentally and physically able to execute their duties. Prioritised access to communications and other critical resources

Role ambiguities:

Regional partners: Local operators who do not have regional partners are particularly challenged to restore operations swiftly

Funding:

Mutual aid: there exist some informal arrangements but no formal cable restoration or mutual aid agreements in place

Facilities sharing:

Towercos: only 1 of 6 surveyed countries has an independent tower company in operation

Spectrum: PPDR spectrum in 694-894 MHz band allocated in all but 1 surveyed country, though not in use in any

Plans: a dearth of national emergency communications plans and communications components within national emergency plans

Planning: telecom regulators generally not involved in the development of national emergency plans nor in the process of emergency planning

Data: despite records of tower locations, there is inadequate data on other infrastructure on which to plan and few jurisdictions can visualize tower locations and metadata on GIS maps

Resilience obligations: Service providers generally have no obligations for network resilience despite some quality of service regulations

Backhaul: heavy reliance on microwave backhaul, less resilient than buried fiber

Underserved communities: No regulatory provisions for new technologies for enhanced reach, e.g. TVWS

Volunteer action: Local and regional HAM operators are active and critical to response and recovery

Formal arrangements: despite rich engagement and action, there are no formal frameworks for HAM operators' engagement and operation in emergencies

Low critical mass: many jurisdictions have low numbers of licensed operators and many are aged
Regulations

- **Energy Prioritization**
 - Maintain listing of key qualified personnel and agencies
 - Arrangements fuel access for key stakeholders
- **HAM Radio Operators**
 - Include Ham Operators formally in Disaster
 - Encourage next generation HAM Operators
- **Installation Codes**
 - Specify minimum standards for building and network installations
 - Define compliance policies
- **Infrastructure Sharing**
 - Require collaboration between operators for co/location and sharing infrastructure
- **Infrastructure**
 - Facilities sharing, to include cable restoration
 - Mutual aid requirement and emergency peering
- **Incentives**
 - Building resilience in communications networks
 - Establishment of cable landing sites, at least 2 per country
- **Spectrum**
 - Public Protection and Disaster Relief (PPDR) spectrum allocation
 - Provision for technologies that enable large coverage
- **Data**
 - **A GIS map of critical communications infrastructure with topography, morphology, critical**

2 Why Resilient Caribbean Communications Infrastructure Matters

The 2017 Atlantic hurricane season was particularly destructive for the Caribbean as six major hurricanes assailed the region. Ten Caribbean countries were devastated by the most ferocious of these, Irma and Maria, both of which were classified as Category 5.

Many communications networks were severely damaged and critical communications services, including broadcast and internet, experienced debilitating disruptions and delays in restoration. Relief efforts were also hampered by the limited availability of technical personnel, and insufficient regulatory and emergency management planning for emergency spectrum and infrastructure sharing. Economic constraints faced by many Caribbean nations further means that several countries can enter each annual hurricane season with more fragile communications infrastructure than the year before. Consequently, the region's capacity to rebound diminishes each year.

Communications is essential to all stages of the disaster management cycle: mitigation, preparation, response and recovery. Without the ability to communicate, citizens, first responders and disaster relief agencies are isolated and unable to access information necessary for safety and recovery. Without effective communications, attempts to mitigate the effects of a disaster or facilitate recovery are seriously compromised.

The telecommunications sector is integral to the economic development and social welfare of the Caribbean. The sector provides a critical enabling role, underlying the operations and activities of all governments, commercial enterprises, organizations and public safety initiatives.

Over the past three decades, the sector has evolved from predominantly a provider of analogue-based audio services into a diverse, globally interconnected industry. The transmission of today's networked, Internet-connected services now spans satellite, wireless, wireline and submarine cable providers. These providers exist within highly interdependent relationships for carrying and terminating data traffic; building, sharing and maintaining facilities and technology; and regulating delivery to end-users. These networks and the diverse actors responsible for them, together form the telecommunications backbone that underpins the modern, digital economy.

3 Problem Statement

The 2017 hurricane season in the Caribbean was devastating to communities, economies and infrastructure. Entire communications networks were destroyed and others severely damaged.

As these networks are vital to economic development, social stability and disaster management, network operators are paying greater attention to resilience-centric design and operation of their infrastructure.

There exists, however, neither a coherent roadmap of policies and regulations, nor an overarching regional strategy to bolster communications resilience in the vulnerable states of the Caribbean.

3.1 The Caribbean Telecommunications Union's Response

Recognising that communications services are key to development and disaster management, and in response to concerns from Member States regarding the debilitating impact of service disruptions, the Caribbean Telecommunications Union (CTU), established a Commission on Caribbean Communications Resilience (CCCR).

As the CARICOM institution responsible for information and communication technologies (ICT) in the Caribbean, the CTU would present policy and regulatory recommendations of the CCCR to its Member States.

The ultimate goal would be to strengthen the procedural environment to support improved disaster readiness and resilience of the region's critical telecommunications sector.

3.2 Commission Mandate

The mandate of the CCCR is to deliver a report that provides a high-level roadmap for governments in CTU member states to contemplate and formulate actionable policy, regulatory, and institutional interventions for greater communications resilience. Though the vulnerabilities of primary concern are weather-related, the roadmap is more broadly applicable.

3.3 Commission Structure

The Commission consists of a Chair, a Vice-Chair, and ten Commissioners drawn from requisite fields of expertise, within the Caribbean and internationally. In addition, five liaisons from industry and government help oversee the work of the Commission, and the CTU Secretariat supports the Commission in its work.

The CCCR Commissioners were selected by the CTU based on technical expertise, personal and institutional objectivity and experience. In order to ensure the

"The commissioners have been selected to preserve the neutrality and integrity of the CCCR"

objectivity of the work of the CCCR, no representatives from industry and regulatory community were included on the CCCR. That is to say that none of the commissioners are from the companies whose service suffered disruptions, nor companies seeking to compete with them, nor regulators with jurisdiction over them. These stakeholder groups, however, are among those who played a central role in providing insights, data and recommendations for the work of the Commission.

3.4 Commission Output

The CCCR report, presents

- i. findings of primary and secondary research undertaken by commissioners;
- ii. actionable recommendations for strengthening policy, and regulatory frameworks;
- iii. other recommendations that would support communications resilience; and
- iv. a roadmap to guide governments in enhancing communications resilience.

3.5 CCCR Guiding Principles

CCCR's analysis and recommendations are grounded in the following principles:

- i. Despite the multivariate nature of weather and climate, the lack of undeniable evidence of changes in tropical cyclone behaviour, and variance of opinion^{1,2,3,4}, a variety of indications suggest the likelihood of more persistent and devastating hurricanes alongside global warming⁵. On this basis, the CCCR finds

¹ Bender, M.A., Knutson, T.R., Tuleya, R.E., Sirutis, J.J., Vecchi, G.A., Garner, S.T., and Held, I.M. (2010) Modeled impact of anthropogenic warming on the frequency of intense Atlantic hurricanes. *Science* 327, 454–458

² Elsner, J. and Jagger, T. (2008) United States and Caribbean tropical cyclone activity related to the solar cycle, *Geophys. Res. Lett.*, 35, L18705. doi:10.1029/2008GL034431.

³ Murakami, H., Mizuta, R. & Shindo, E. (2012) Future changes in tropical cyclone activity projected by multi-physics and multi-SST ensemble experiments using the 60-km-mesh MRI-AGCM, *Climate Dynamics* 39 (9), 2569-2584. doi:10.1007/s00382-011-1223-x

⁴ Elsner, J., Kossin, P., and Jagger, T. (2008) The increasing intensity of the strongest tropical cyclones, *Nature*, 455, 92- 95.

⁵ Mimura, N., L. Nurse, R.F. McLean, J. Agard, L. Briguglio, P. Lefale, R. Payet and G. Sem, 2007: Small islands. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the*

that there is cause for a systemic resilience-centric ethos in the development and operations of critical telecommunications infrastructure in the Caribbean.

- ii. Telecommunications is one of a number of critical sectors.
- iii. Weather- and climate-related disasters are not the only phenomena that put telecommunications infrastructure, and by extension public telecommunications services, at risk. Nevertheless, this is an area of vulnerability shared across all sectors and is of particular significance to small island developing states. Resilience to these disasters provides an opportunity for closer integration of the telecommunications sector into regional and national critical infrastructure planning and management.
- iv. Ancillary services such as power and environmental control are considered intrinsic to critical communications infrastructure. All infrastructure is not critical, neither are all services.
- v. Critical infrastructure is a public good, managed and in many cases owned by private concerns.



Telecommunications infrastructure in the aftermath of 2017 hurricanes in the Caribbean. Damage to communications infrastructure left citizens isolated and thwarted the recovery efforts of first responders.

How can the Caribbean develop resilient communications?

What is the role of governments in fostering communications resilience?

Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 687-716.

4 CCCR Study

4.1 CCCR Scope

The scope of the CCCR's 2018 examinations are circumscribed by hazard category, geography sector, and target audience:

Study scope by hazard

Climate-related events and impacts constitute the primary category of hazards of concern to the CCCR.

Study scope by sector

The Commission's work is limited to the communications sector, in particular all electronic communications services that support emergency mitigation, preparation, relief, response and recovery. These include traditional telecommunications and internet services as well as free to air TV and radio broadcasting, and amateur radio.

Study scope by target audience

As a study led by the Caribbean Telecommunications Union (CTU), the primary audience for the CCCR report comprises national and regional agencies in CTU countries that carry responsibility for policy and regulation concerning communications and disaster management.

Study scope by geography

The jurisdictions from which CCCR's 2018 primary research is drawn include a sample of CTU countries hard hit by hurricanes in 2017 (Anguilla, Antigua and Barbuda, Dominica, Saint Maarten and the British Virgin Islands); as well as Grenada as a control.

4.2 Methodology

The work of the CCCR was executed primarily via video-conference, teleconference, email and in-country interviews. Information was collected via several data gathering channels which included survey instruments produced by the CCCR, interviews with key stakeholders, desk research and discussion with stakeholders drawn from national, regional and international organisations in the communications industry. The information gathered was analysed and used to inform the CCCR's recommendations

The survey instruments comprising quantitative and qualitative elements were prepared through consultations with a broad cross-section of stakeholders within and outside of the Caribbean over several weeks.

The CTU directly sought permission from respondent agencies to complete the surveys. Follow-up interviews were conducted when required to seek clarification or further information based on responses received.

Specifically, the CCCR :

- i. gathered facts about communication network failures and pace of recovery for representative countries

- ii. determined which factors contributed most significantly to network outages, and restoration delays
- iii. reviewed policy approaches and regulations, legislation that facilitate network resilience and rapid disaster-recovery
- iv. developed recommendations for strengthening policy, legislation and regulation development; human resource capacity; infrastructure planning, and disaster management.

4.3 Findings, Assessment and Recommendations








The information collected was categorised and assessed according to five categories that have been defined to incorporate the disaster management function in its entirety. The categories are listed and explained below.









- **Formal emergency ecosystem** encompasses all of the organisations involved in the provision of disaster management services, communication service providers; the relationships, plans, systems and processes involved in disaster management.
- **Resilience planning and resourcing**
- **Service Availability** refers to the provision of communication services to key individuals involved in the disaster response process, first responders, senior government officials and persons with special needs.
- **Service Reach** addresses the issue of geographic coverage for communications services
- **Volunteers for Emergency Ecosystem** are other informal organisations and individuals that may contribute significantly to the disaster management process.

5 Public Policy Assessment and Recommendations

5.1 Policy Scorecard

The following table presents a summary of the findings of the research conducted primarily with policy makers and other practitioners who provided information which could impact policy. The information is presented in a scorecard.

Policy Area	Rating	Summary of Findings
Formal emergency ecosystem		Collaborative relationships: There is a need for formalising and strengthening collaborative relationships between all relevant national, regional and international agencies.
		Disaster Management Plans: Countries have a strong suite of emergency plans
		Communications Plans: The importance of communications in the disaster management process has to be reflected in the emergency plans
		Coordination and Execution There is need for greater coordination oversight in the execution of plans.
		Cooperation Agreements: Establishment of formalised agreements between responding Agencies are necessary.
Resilience planning and resourcing		Financial mechanisms for Fostering Resilience: Availability of special funds and financial incentives could foster greater network resilience
		Building Codes: Specify minimum standards for buildings housing critical communications infrastructure.

Policy Area	Rating	Summary of Findings
		Critical Infrastructure Standards: Specify minimum standards for critical communications infrastructure installations
		Infrastructure sharing: To the extent practicable mandate infrastructure sharing.
		Information Availability: Building and sharing comprehensive databases including critical communication infrastructure installations and emergency resources is necessary
		Priority Access: There is the need to enhance prioritised access to communications and other critical resources
		Responder Readiness: Provisions must be made to ensure that responders are mentally and physically able to execute their duties.
Service Availability		Service Continuity: Minimum standards must be established for service delivery to different classes of stakeholders to ensure that communication services are available throughout the disaster or soon thereafter.
Service Reach		Network Coverage: Disaster management agencies must be able to communicate with all citizens. Network coverage with appropriate communications channels must be ubiquitous.
Volunteers for Emergency Ecosystem		Strengthening the Ecosystem: The role of Broadcasters, HAM Operators other IT/Network professionals with the capacity to strengthen the ecosystem must be formalised in the disaster management process.

5.2 Public Policy Strategy

The significance of and requirement for continuous communications services as an integral part of the disaster response must be recognised in order to promote the safety and security of citizens in disaster situations. While disaster management is a collective

responsibility and national governments are best suited for coordination, given the importance of communications in disaster management. There is therefore a need for ensuring that appropriate policies are in place to foster continuous communications in all stages of disaster management, namely mitigation, preparedness, response and recovery.

Public policies must seek to enhance communications resilience by:

- i. Establishing and strengthening collaborative relationships between all relevant agencies and partners, nationally, regionally and internationally;
- ii. Developing and maintaining appropriate plans, periodically testing and amending them and coordinating the roles and responsibilities of all contributors to the disaster management process;
- iii. Mandating the establishments of operational agreements response agents for disaster situations and the specification of standards;
- iv. Fostering resilient, flexible and adaptable communications infrastructure and adopting risk-management approaches; and
- v. Requiring the consistent collation, sharing and protection of information pertaining to communications infrastructure and personnel.

The following section presents policy statements and the specific recommended actions to address the gaps and issues highlighted in the findings of the CCCR presented in Section 7.1.

The recommended actions are arranged according to their relevance to the five categories of disaster management functions defined in section 6.3. In addition the recommendations are also classified according to the four stages of disaster management identified earlier.

Given the diversity that exists in CTU Member States, these recommendations should be considered in the context of the national circumstances, Nevertheless those that are of relevance, will serve to strengthen the communications policy framework in CTU Member Countries.

5.3 Policy Recommendations

5.3.1 Formal Emergency Ecosystem

A comprehensive emergency ecosystem of diverse communities of interest must be established long before the onset of an emergency.

5.3.1.1 Policy: *Disaster management will require the participation of national, regional and International agencies. Personnel must be assigned and systems put in place to facilitate their engagements and interventions*

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> Establish relationships with regional and international response and communications organisations and foster cooperation and collaboration on a continuing basis

5.3.1.2 Policy: *Regional and international collaboration must be encouraged as part of the disaster management process.*

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> Involve regional and international response agencies in the as collaborators in appropriate national DM processes on a continuing basis

5.3.1.3 Policy: *Coordination of regional and international players whose activities must also be incorporated in the DM process.*

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> Recognizing Amateur radio service, defined under ITU-Radio Regulations R 53 and R 54, CTU member countries should sign to the Tampere Convention and revised International Amateur Radio Permit that allows the movement of radio operators and communication equipment in to affected areas. Develop an archive of best practices and facilitate fora for sharing Caribbean experience and best practice. Establish a data exchange for contact information, standards and forms for emergency communications reporting (missing persons, health, logistical etc.) through appropriate systems such as WinLink. Promote regional networks e.g. the daily CEWN to test and assess communications, establish links and relationships to discuss, learn, and exchange information. Promote amateur radio licensing, regular use and establishment of nodes and services by the research and academic communities Promote regional proliferation of DMR.
Preparedness	<ul style="list-style-type: none"> Create a database of amateur radio systems, equipment and interoperability options. Enable multiple channels to contact the outside world e.g. through more Winlink stations and EchoIRLP nodes setup in the Caribbean. Include amateur operators with emergency communication stations and accessories on teams deployed for relief operations. Hold regional policy fora to recognize the importance of amateur radio

	<p>specifically to influence local governments' support for duty and license concessions, and development & deployment plans.</p> <ul style="list-style-type: none"> • Facilitate more regional cooperation, group meetings and practical exercises between DMAs and HAMS • Develop a regional emergency communication template and plan for CARICOM • Support regular linking of repeaters (VHF/UHF) between islands to increase camaraderie and allow for rapid regional emergency communications
Response	<ul style="list-style-type: none"> • Ensure field personnel provide health and welfare messages from persons in affected areas to assigned amateur radio operators for relaying to family abroad.

5.3.1.4 Policy: *Cooperation agreements are necessary instruments for disaster management and therefore must be established.*

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Establish formal arrangements (MOU) with emergency management authority for early warning notification, standard message broadcast, regular updating, etc. • Establish similar arrangements with other stakeholders such as Fire Services, Police, other broadcasters, service providers, fuel delivery, equipment suppliers, etc. • Establish MOUs with Amateur Society and clubs and issue NEOC access IDs to trained personnel • Establish agreements for: <ul style="list-style-type: none"> ▪ Restoration and recovery mutual aid amongst service providers and between service providers and other critical agencies ▪ Broadcasters and formal arrangements with emergency management authority for early warning notification, standard message broadcast, regular updating, etc. • Establish formal arrangements with other stakeholders such as Fire Services, Police, other broadcasters, service providers, fuel delivery, equipment suppliers, etc.
Preparedness	<ul style="list-style-type: none"> • Participate in emergency drills done by other key stakeholders and invite involvement in one's own exercises to help build a more cohesive response program.

5.3.1.5 Policy: The role of Broadcasters must be formalised in the national disaster management framework.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Include broadcasters formally in Disaster Preparation and Management process.

5.3.1.6 Policy: The role of HAM operators and other volunteer communities must be formalised in the national DM framework.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Include Amateur radio representatives formally in disaster preparation and management process.
Preparedness	<ul style="list-style-type: none"> • Strengthen the Amateur Radio operators' community

5.3.1.7 Policy: High barriers and impediments to execution of DM plans must be removed.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Ensure that there is a national emergency communications plan which sets out the role of amateurs, radio provisions, training and exercising. • Promote support for resident amateur operators in underserved communities and existing service-based clubs. • Provide suitable building for administrative office, club station, secure storage for rapid response equipment, experimental laboratories and youth development and training.
Preparedness	<ul style="list-style-type: none"> • Facilitate access to towers at high elevations for instalment of repeaters. • Facilitate local internet connectivity to all amateur VHF/UHF repeaters to enable a VoIP backbone throughout the Caribbean.
Response	<ul style="list-style-type: none"> • Waive duties and VAT on Amateur radio equipment, including solar facilities. • Waive annual license fees for amateur radio operators.
Recovery	<ul style="list-style-type: none"> • Ensure that there is a national emergency communications plan which sets out the role of amateurs, radio provisions, training and exercising. • Promote support for resident amateur operators in underserved communities and existing service-based clubs. • Provide suitable building for administrative office, club station, secure storage for rapid response equipment, experimental laboratories and

Disaster Stage	Recommendation
	youth development and training.

5.3.1.8 Policy: Disaster management plans must recognise the significant role of communications in the DM process.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Develop streamlined plans including communication plans based on the inputs of the agencies and personnel identified in the DM ecosystem • Engage regional and international response agencies and other Caribbean countries in the formulation of the national plans
Preparedness	<ul style="list-style-type: none"> • Plans must be exercised periodically and updated appropriately • Ensure the requirements of the plans are adhered to • Conduct national drills prior to the commencement of the Hurricane season
Response	<ul style="list-style-type: none"> • Execute plans
Recovery	<ul style="list-style-type: none"> • Assess and report on damage and recovery needs

5.3.2 Resilience Planning and Resourcing

A comprehensive emergency ecosystem of diverse communities of interest must be established long before the onset of an emergency.

5.3.2.1 Policy: Funding mechanisms must be established to foster communications resiliencies.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Establish a fund for building resilience • Examine the use of USF for encouraging communications resilience. • Establish mechanisms for providing incentives for building resilience
Preparedness	<ul style="list-style-type: none"> • Provide incentives for investment in emerging resilient technologies
Recovery	<ul style="list-style-type: none"> • Provide incentives for investment in emerging resilient technologies for recovery and restoration

5.3.2.2 Policy: Mechanisms to encourage the use of new more resilient technologies must be established

Disaster Stage	Recommendation
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Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> Institute Government incentives for technology refresh Establish a fund for building resilience.

5.3.2.3 Policy: Technology life cycle risks are to be considered in fostering resilience

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> Require periodic reporting among the parties on their plans to update the technologies in use or the retirement of aging plant. Provide Incentives for making use of new technologies.

5.3.2.4 Policy: Standards and codes must be specified to ensure resilience-hardened buildings and installation.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> Establish building construction standards in accordance with international best disaster practices.
Preparedness	<ul style="list-style-type: none"> Specify minimum standards for building and network installations
Recovery	<ul style="list-style-type: none"> Harden all repeater facilities Avoid land slide/flooding prone areas for new installations

5.3.2.5 Policy: Due consideration must be given to building network resilience to ensure service continuity during a disaster.

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> The networks must be built with sufficient redundancy to avoid a single point of failure Networks to be engineered for diversity (space/technology)
Recovery	<ul style="list-style-type: none"> Maintain Inventory current equipment stock Assess current equipment stock for technology and geographic interconnectivity Fill gaps in equipment and technology Install nodes at hardened facilities including the NEOC Use national emergency communications plan as the base for training and exercising Add Internet equipment and software for internet service via amateur

Disaster Stage	Recommendation
	radio in EOCs

5.3.2.6 Policy: *Sharing of Infrastructure must be encouraged*

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Mandate that infrastructure is shared by service providers especially in the disaster situation • Set standards for infrastructure sharing
Preparedness	<ul style="list-style-type: none"> • Ensure that the standards for infrastructure sharing are adhered to.
Recovery	<ul style="list-style-type: none"> • Mandate the sharing of infrastructure to expedite service restoration.

5.3.2.7 Policy: *Emergency awareness must be incorporated in standard operating procedures.*

5.3.2.8 Policy: *Availability of current reliable and appropriate information has to be a standard element of the disaster management response.*

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Create a national response database of critical facilities as well as key support services so that efforts can be prioritized and resources optimally assigned and utilized.
Preparedness	<ul style="list-style-type: none"> • Establishment and maintenance of current replicated databases and /or registries for: <ul style="list-style-type: none"> ▪ critical communications and ancillary installations ▪ key emergency support national, regional and international agencies and personnel and contact information ▪ Emergency resources (fuel, power, transport, rigging etc.) and arrangements for priority access on consignment, are included in the NRD • GIS and other information systems should be used. • All information must be freely available to relevant agencies and responders • Information must be shared and to the extent possible, made open.

5.3.2.9 Policy: Priority access to key resources must be afforded to response personnel.

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> Specify the provisions to be made for security and physical access to key installations and availability and access to resources on consignment.

5.3.2.10 Policy: The allocation of energy and other critical resources must be prioritised for first responders and senior government officials and provisions are to be made for energy continuity during a disaster.

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> Maintain listing of key personnel and agencies to be supplied Establish special storage arrangements for critical resources.
Response	<ul style="list-style-type: none"> Establish special storage arrangements to make fuel, communication devices and other resources available and accessible to key stakeholders Install alternative power sources for key repeaters in each territory <p>Short-term:</p> <ul style="list-style-type: none"> Ensure independent back-up power capability to continue operations for at least 24 hours. Also establish plans to continue for an additional 48 hours (fuel supply and delivery, etc. Ensure critical spares are available on site and can be retrieved at a moment's notice. Where cost is an issue, establish MOU with industry partner or supplier for loan/ purchase in emergency. <p>Longer Term:</p> <ul style="list-style-type: none"> Build in backup power capacity for 3-day operation Replicate mission critical servers, locally and internationally

5.3.2.11 Policy: Provisions must be made to ensure that first Responders and other key personnel are physically and mentally available to perform their duties.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> Establish weather resistant accommodation with all that is necessary to house key responders and assure their safety and that of their families and enable them to perform their duties .
Preparedness	<ul style="list-style-type: none"> Equip accommodations with potable water and food, electricity and communications facilities. Make specific provisions for security and physical access to key installations

Disaster Stage	Recommendation
	and availability and access to resources on consignment.

5.3.3 Service Availability

5.3.3.1 Policy: Minimum standards for service continuity and delivery during a disaster must be specified.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> A minimum standard for service delivery must be specified and assured for key personnel during an emergency.

5.3.3.2 Policy: Mechanisms must be established to encourage service providers to use technologies that enhance network coverage and build resilience.

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> Institute Government incentives for build-out of resilient networks

5.3.4 Service Reach

5.3.4.1 Policy: First responders, senior Government officials and representatives of key response agencies must have access to continuous communications services during a disaster.

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> Maintain updated list of key stakeholders and agencies for priority access to communication services. Ensure that appropriate systems are in place to ensure access to and use of appropriate communication services.

5.3.4.2 Policy: Provisions must be made for Persons with disabilities and seniors to have access to communication services or information.

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> Establish systems to ensure that People with disabilities and seniors have access to communication services and the necessary information to secure their safety

5.3.4.3 Policy: Diverse communication channels must be available to ensure that information/content can be disseminated to the population.

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> Minimize dependence on single means of distribution by utilizing other available connectivity options.

5.3.4.4 Policy: Broadcasters must have access to international connectivity.

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> Consideration should be given to having at least 2 means of accessing international media. Should primary be disrupted, content can still be accessed via satellite, microwave, etc. This should be independent of local service providers since they may all be similarly affected.

5.3.5 Volunteer Emergency Ecosystem

5.3.5.1 Policy: HAM Operators must be ready and equipped to provide continuous emergency communications in a disaster.

Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none"> Strengthen human capacity in the area of emergency communications in National disaster offices Encourage regular (daily) use of amateur equipment to ensure operator competence and good working order of equipment. Mechanisms include low barriers to entry and maintenance; as well as a rich and the existence of a vibrant community

Disaster Stage	Recommendation
	<ul style="list-style-type: none"> • Conduct routine cross training and exercising between emergency response agencies • Operations Centre for amateur and other radio operators • Add Internet equipment and software for internet service via amateur radio in EOCs • Establish MOUs with Amateur Society and clubs and issue NEOC access IDs to trained personnel
Recovery	<ul style="list-style-type: none"> • Outfit active amateur radio emergency clubs with radio kits containing an HF & VHF transceiver for both voice and data modes; and portable repeaters • Conduct routine preparation exercises in National Emergency

5.3.5.2 Policy: *A new generation of HAM Operators must be cultivated.*

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none"> • Run sustained marketing and recruitment campaigns, particularly targeted at youth and women, on emergency • Conduct regular diverse activities and training that generate interest in ham radio and emergency communications • Introduce HAM activities in schools through school clubs communications and amateur radio • Deliver Caribbean webinars on emergency communications and amateur radio, with resonant taglines • Make exams and course material readily accessible • Encourage adoption and experimentation within schools, universities and national science centres •

5.3.5.3 Policy: Competent ICT Expertise must be available to support disaster relief operations

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none">• Incorporate ICT Experts in the formal DM processes.
Preparedness	<ul style="list-style-type: none">• Maintain a pool of competent ICT persons from national, regional and international sources









5.3.5.4 Policy: Diverse communication channels must be available to ensure that information/content can be disseminated to the population









Disaster Stage	Recommendation
Preparedness	<ul style="list-style-type: none">• Minimize dependence on single means of distribution by utilizing other available communication channels and connectivity options.

6 Regulatory Assessment and Recommendations

6.1 Regulatory Scorecard

The following table presents a summary of the findings of the research conducted primarily with regulators. Also included are inputs from other practitioners who provided information which could impact regulations. The information is presented in a scorecard

Resilience Pillar	Regulatory Scorecard	Summary of Findings
Formal emergency ecosystem		Role ambiguities: need for added clarity in roles and priorities of various agents in the emergency ecosystem to ensure efficient response and recovery.
		Regional partners Local operators who do not have regional partners are particularly challenged to restore operations swiftly
Resilience planning and resourcing		Funding: no funding mechanisms for network resilience; Universal Service Funds, where they exist, generally do not provide for resilience
		Mutual aid: there exist some informal arrangements but no formal cable restoration or mutual aid agreements in place
		Facilities sharing: only 2 of 6 surveyed countries have regulations that mandate facilities sharing between
		Towercos: only 1 of 6 surveyed countries has an independent tower company in operation
		Spectrum: PPDR spectrum in 694-894 MHz band allocated in all but 1 surveyed country, though not in use in any
		Plans: a dearth of national emergency communications plans and communications components within national emergency plans

Resilience Pillar	Regulatory Scorecard	Summary of Findings
		Planning: telecom regulators generally not involved in the development of national emergency plans nor in the process of emergency planning
		Data: despite records of tower locations, there is inadequate data on other infrastructure on which to plan and few jurisdictions can visualize tower locations and metadata on GIS maps
Service availability		Resilience obligations: Service providers generally have no obligations for network resilience despite some quality of service regulations
		Backhaul: heavy reliance on microwave backhaul, less resilient than buried fiber
Service reach		Underserved communities: No regulatory provisions for new technologies for enhanced reach, e.g. TVWS
Volunteer Emergency Ecosystem		Volunteer action: Local and regional HAM operators are active and critical to response and recovery
		Formal arrangements: despite rich engagement and action, there are no formal frameworks for HAM operators' engagement and operation in emergencies
		Low critical mass: many jurisdictions have low numbers of licensed operators and many are aged

6.2 Regulatory Strategies

Telecommunications regulators are responsible for ensuring that services are delivered in accordance with public interest, through a regulatory framework which promotes and enables:

- i. access to affordable service for all citizens regardless of location, physical ability and economic status

- ii. consumer protection with respect to service choice, pricing, availability and quality of service
- iii. investment, fair competition and efficient use of national resources (such as spectrum and numbers).

The regulatory framework comprises various regulatory instruments to effect regulatory objectives. Of most relevance to the disaster management cycle (mitigation, preparedness, response and recovery) are those that govern access to facilities and interconnection, spectrum management, quality of service, pricing, universal service, and all related matters.

The regulatory function requires a great deal of planning, monitoring, assessment and analysis, all of which require data, to ensure that its objectives are met for the public good. A key aspect of the regulatory function is also the enduring engagement with very many agents across multiple sectors.

The following section summarizes nominal recommendations for inclusion in the telecommunications regulatory framework of CTU countries. Each is to be considered in the national context as local circumstances may render particular recommendations in applicable or inadvisable.

The recommendations are classified according to the four stages of disaster management namely, mitigation, preparedness, response and recovery.

6.2.1 Regulatory Domain: Access to facilities and interconnection

Disaster Stage	Recommendation
Mitigation	<p>Include regulations for:</p> <ul style="list-style-type: none"> Facilities sharing, to include cable restoration, mutual aid requirements and emergency peering (as appropriate) under emergency circumstances <p>Offer incentives for:</p> <ul style="list-style-type: none"> Independent tower companies with strict requirements for resilience, access and coverage Establishment of an ideal number of cable landing sites, at least 2 per country
Preparedness	<ul style="list-style-type: none"> Enforce facilities sharing regulations Ensure that cable restoration & mutual aid arrangements & agreements in place

6.2.2 Regulatory Domain: Spectrum management

Disaster Stage	Recommendation
Mitigation	<p>Include in spectrum authorization framework:</p> <ul style="list-style-type: none"> Public Protection and Disaster Relief (PPDR) spectrum allocation to include bands used by neighbouring countries (to facilitate ease of assistance in response and recovery) Provision for TVWS and other technologies that enable large coverage <p>Include in operators' spectrum license:</p> <ul style="list-style-type: none"> Transmission of emergency tones & national emergency broadcasts (broadcasters) <p>Offer incentives for:</p> <ul style="list-style-type: none"> Resilience-focussed pilots, innovations and deployments Ham operators via low licensing fees and waivers for students, schools and community organizations Development of a national amateur radio relay system with capability of interconnecting to neighbouring countries via the internet and via direct HF and microwave
Preparedness	<ul style="list-style-type: none"> Disaster resilience audits and business continuity plans Broadcasters issue emergency tones and national emergency broadcasts
Response	<ul style="list-style-type: none"> Include in spectrum authorization framework or regulatory practice: Waiver of fees for spectrum required for relief until the recovery period is underway

6.2.3 Regulatory Domain: Quality of Service

Disaster Stage	Recommendation
Mitigation	<p>Include regulations for:</p> <ul style="list-style-type: none"> Quality of service, to include resilience standards specified in terms of network availability Submission of information, to include georeferenced critical infrastructure for inclusion in a national resilience database <p>Include in network operators' concession:</p> <ul style="list-style-type: none"> Resilience standards, as per QoS regulations Requirement for georeferenced data for all critical infrastructure, as per

Disaster Stage	Recommendation
	<p>submission of information regs</p> <p>Offer incentives for:</p> <ul style="list-style-type: none"> • Burying fiber • Building back better
Preparedness	<ul style="list-style-type: none"> • Review with other agents in the emergency communications ecosystem: • Critical communications infrastructure in the georeferenced national resilience database to assess areas of particular vulnerability • All new network builds and extensions to be routable with gateways to facilitate inter-networking with multiple platforms and technologies
Recovery	<p>Include in network operators' concession, requirements for:</p> <ul style="list-style-type: none"> • Emergency restoration • Reporting on infrastructure failure and damage, and corresponding service impact, along the lines of CANTO's Disaster Status Report submitted to regulator following each disaster

6.2.4 Regulatory Domain: Pricing

Disaster Stage	Recommendation
Mitigation	<p>Include in regulations:</p> <ul style="list-style-type: none"> • Provisions for zero rated roaming on declaration of state of emergency

6.2.5 Regulatory Domain: Universal Service

Disaster Stage	Recommendation
Mitigation	<p>Maintain:</p> <ul style="list-style-type: none"> • A GIS map of critical communications infrastructure with topography, morphology, critical infrastructure (roads, power distribution points, ports, priority agents etc.) • An electronic national emergency communications network diagram comprising all critical communications infrastructure, their estimated coverage, capacity and interconnectivity • Utilize USF to harden entire infrastructure chain (international connectivity, core and access) to underserved communities where allowed by law

6.3 Starter Activities

Need a blurb.

6.3.1 Formal Emergency Ecosystem

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none">• Telecoms regulator to play active role in emergency ecosystem

6.3.2 Resilience Planning and Resourcing

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none">• Develop a model national resilience database• Develop a draft model NECP for CTU countries and associates and host a regional workshop to assess and finalize the model NECP. Countries to share localized plans• Develop emergency communications checklists for key agencies, social services and communities along the lines of CANTO's Hurricane Emergency Procedure Template
Recovery	<ul style="list-style-type: none">• CDEMA Rapid Needs Assessment Team (RNATs) to include assessment of communications infrastructure relief and recovery needs

6.3.3 Service Availability

Disaster Stage	Recommendation
Mitigation	<ul style="list-style-type: none">• Develop model resilience standards• Incorporate resilience standards into CANTO's <u>Disaster Recovery Planning (DRP)</u> and regulatory frameworks
Recovery	<ul style="list-style-type: none">• Enact legislation to waive duties on communications restoration equipment

7 Findings of Secondary Research

7.1 Body of Knowledge

There exists a considerable body of knowledge relevant to the communications aspects of the disaster management cycle (mitigation, preparedness, response and recovery). This includes but is not limited to:

- i. Guidelines and best practice for emergency and resilient telecommunications such as [*ITU's Handbook on Emergency Communications \(2005\)*](#) and [*Compendium of ITU's work on Emergency Telecommunications*](#) (2007)
- ii. Standards and recommendations relating to emergency communications such as ITU-T Y.1271⁶ for network requirements and capabilities, ITU-R M.2009-1⁷ for radio interfaces, M.2015-2⁸ for spectrum, ITU-T X.1303⁹ for an alerting protocol, ITU-T L.92¹⁰ for hardening the outside plant
- iii. Background studies such as the ITU's *Assessment of Emergency Telecommunication plans and systems in the Caribbean Region (2017)* and [*Question 5/2: Utilization of telecommunications/ ICTs for disaster preparedness, mitigation and response \(2017\)*](#)
- iv. International agencies and collaboratives available for assistance with recovery such as the [*ITU*](#), [*NetHope*](#) and the [*ETC*](#) for emergency equipment including satellite phones and terminals, solar equipment and accessories, training, airtime, freight costs etc.

⁶ [*Y.1271 : Framework\(s\) on network requirements and capabilities to support emergency telecommunications over evolving circuit-switched and packet-switched networks*](#)

⁷ [*M.2009-1 Radio interface standards for use by public protection and disaster relief operations in some parts of the UHF band in accordance with Resolution 646 \(Rev.WRC-12\)*](#)

⁸ [*M.2015-2 Frequency arrangements for public protection and disaster relief radiocommunication systems in accordance with Resolution 646 \(Rev.WRC-15\)*](#)

⁹ [*ITU-T X.1303 Common alerting protocol \(CAP 1.1\)*](#)

¹⁰ [*ITU-T REC-L.92-10/2012 Series L: Construction, installation and protection of cables and other elements of outside plant: Disaster management for outside plant facilities.*](#)

- v. disaster-focused industry and sector collaboration instruments such as the Letter of Intent (LOI) on the use of ICTs for emergency and disaster situations in the Americas region between CTU, ITU, CITELE and COMTELECA, GSMA's [Humanitarian Connectivity Charter](#) and the satellite community's [Crisis Connectivity Charter](#)
- vi. Narrative assessments of impact of, and needs arising from, 2017 hurricanes in the Caribbean, such as those facilitated by the [Government of the Commonwealth of Dominica](#), the Government of Antigua and Barbuda, [UNDP](#), [ACP-EU](#) and the [GSMA](#).
- vii. A few examples of map-based assessments such as available from [Map Action](#) for [Anguilla](#), British Virgin Islands ([BVI](#)), regrettably not in machine-readable format.
- viii. Current initiatives to strengthen the resilience of Caribbean communications networks. Such initiatives include but are not limited to the ITU's winlink,
- ix. Capacity building: ITU-facilitated regional workshop to assess technical capacity building needs in emergency communications for first responders, policy makers and regulators in Q4 2018.

7.2 Documented findings from 2017 hurricanes

Multiple assessments of 2017 hurricanes in the Caribbean (*ref Dominica, ref Antigua, ref PR, ref BVI, GSMA, Louis etc, as applicable*) revealed, unsurprisingly, that the primary sources of service interruptions were damage to the outside plant and losses in power.

Key outside plant infrastructure comprises poles, towers, other aerial structures and their payloads: cables, transceiver equipment and antennas. While many core network facilities were hardened and much of the transmission cable buried, the distribution facilities within the "middle mile" were hard hit. These facilities reside between the core and access networks (*I will differentiate between nets for different markets*) and, among other things, carry the backhaul. With the middle mile compromised, so too is service to end-point critical facilities: hospitals, government centers, community centers, cell towers, distribution grid, etc.

Power failures and limited backup power capacity were common features across all affected jurisdictions (*ref Dominica, ref Antigua, ref PR, ref BVI, GSMA, Louis etc, as applicable*). This was as much the case for the telecommunications infrastructure as for the critical facilities where it terminated. As was the case for the telecommunications networks, the weakest links in the power chain were transmission and distribution.

Generation facilities remained largely intact. Hundreds of telecom nodes and thousands of end systems (e.g. cellphones, laptops) that need a daily recharge.

8 Roadmap for Building Communications Resilience

Bevil – Roadmap

The findings of the preceding sections point to the fact that the attainment and maintenance of the goal of communication resilience is both complex and costly, requiring the involvement of many diverse national, regional and international stakeholders and investment in infrastructure and technology by service providers. Additionally, building communication resilience takes time and requires continuous review and updating of update of all systems that support communications resilience.

Because the Caribbean countries most susceptible to hurricanes are relatively small, it is quite possible, as we saw in 2017 that several countries may be incapacitated with the passage of a single hurricane, therefore regional systems must also be put in place to foster communications resilience.

The Government has a unique role to play in establishing the necessary policy, legislative and regulatory frameworks that would foster communications resilience. This Roadmap presents the recommendations identified in the Findings in 5 periods as follows:

8.1 Very Early Activities

The implementation of these recommendations will take time and therefore are identified first.

8.1.1 Funding for Fostering Resilience

There is a cost to fostering resilience in communications services therefore Governments are encouraged to:

- Establish a fund for promoting communications resilience. This could perhaps be done through existing Universal Service Funds
- Provide incentives to encourage the adoption of resilient emerging communications technologies such as TVWS, LEO, MEO and NANO satellite technologies.

8.1.2 Buildings and communication Installation codes

- Establishment minimum codes and standards for

- Building and communications installations
- Building and Installation location including towers.
- Emergency Power

1.

8.1.3 General Provisions

- Introduce mechanisms to waive legislative provisions which pose impediments to:
 - Import of communications equipment to facilitate recovery
 - Free movement of responders
 - Use of spectrum to aid relief and recovery
- Introduce an authorization framework for the use of emerging technologies that use radio frequency spectrum
- A framework must be established to require network operators collaborate on the sharing of infrastructure as a principle for network build out and national coverage.

8.1.4 Obligations for Public Broadcasters

Measures must be put in place in order to exploit the full potential of the broadcast industry. They should be required to:

- Participate fully in the disaster management planning activities
- Increase back-up power capacity to 3-day operation
- Replicate mission-critical servers locally and internationally
- Consideration should be given to having at least 2 means of accessing international media independent of local service providers to ensure that content can still be accessed via satellite, microwave, etc.
- Minimize dependence on single means of distribution by utilizing other available connectivity options.
- Audit and report disaster resilience and business continuity plans.

8.1.5 Obligations for Network Operators

- Facilities sharing to the extent possible should be mandatory
- Mandate:
 - Resilience standards
 - At least 2 cable landing sites
 - New network installations are routable with gateways to facilitate inter-networking with multiple platforms and technologies
 - Hardened construction for communications facilities.
- Establish mechanisms for
 - Resilience audits
 - Ensuring business continuity planning
- Operators should be required to file periodic reports on technology refresh plans especially in the case of retirement of aging plant.
- Communications networks must be built with sufficient redundancy and diversity to avoid single points of failure
- Communications network operators must be required to provide continuous communications for stakeholders and expedited restoration of services should they fail, according to:
 - Pre-determined prioritized list of key personnel including first responders
 - Minimum standard for service delivery

8.1.6 Cultivate a new generation of HAM Operators

- Introduce amateur radio into school activities
- Provide government support for HAM Operator Agencies
- Encourage the development of HAM operator capacity
- Address the needs of the amateur radio community.

8.2 Early Activities

<TEXT HERE>

8.2.1 Information Requirements

- Having valid current information is an important aspect of building resilience. Databases of information for the following should be mandatory:
 - Disaster Management agencies and ancillary organisations and their capabilities
 - Contact details of all stakeholders, national, regional and international..
 - Registries of emergency support services and resources and arrangements for priority access to them.
 - GIS information for all critical communications systems and ancillary installations including broadcasters and HAM Operators
- The databases should be updated periodically and in particular before the onset of the hurricane season to ensure validity
- Mechanisms must be established to ensure that information is shared freely amongst emergency agencies and to the extent possible, made open.

8.2.2 Preparatory Planning Considerations (General)

- Include all stakeholders including HAM Operators, broadcasters and other ICT experts who may provide useful emergency services in planning activities
- Liaise with and engage regional and international stakeholders (including other Caribbean countries and relief organisations) as collaborators in the planning process as well responders as applicable;
- Due attention must be paid to the prioritization of, storage and allocation of communication and energy resources (fuel, communication devices, generators etc.)
- Develop a National Emergency Communication Plan for providing access to continuous communication systems during a disaster
 - For key stakeholders
 - ensuring the public is kept informed

- addresses the particular needs of people with disabilities
- identifying the role of HAM operators and broadcasters
- Establish Emergency communications checklists for key agencies

8.2.1 Preparatory Planning Considerations (Human resources)

First responders must be physically and mentally prepared to execute their duties. Therefore

- Weather resistant accommodation with all that is necessary to house key responders and assure their safety and that of their families and enable them to perform their duties
- Such accommodation must have potable water and food, electricity and communications facilities.
- Specific provisions must be made for security and physical access to key installations and availability and access to resources on consignment.

8.2.2 Agreements

- Agreements for restoration and recovery mutual aid must be formulated and established in advance of a disaster. These will include:
- Agreements for restoration and mutual aid amongst service providers and between service providers and other critical agencies
- Broadcasters in particular should be required to establish
- Formal arrangements with emergency management authority for early warning notification, standard message broadcast, regular updating, etc.
- Formal arrangements with other stakeholders such as Fire Services, Police, other broadcasters, service providers, fuel delivery, equipment suppliers, etc.

8.2.3 The Plans

- Establish, document and circulate plans for dealing with disasters. The plans must identify streamlined efficient systems and procedures for addressing disasters. Consider

- The best suited recovery/response agencies and their capabilities
- Escalation and Communication Plans for national emergency management
- Countries can respond in cases of total devastation
- Network Operations Centres procedures including infrastructure and communication equipment (satellite phones) and protocols
- The role of Amateur Radio Operations and Broadcasters
- Early warning systems
- Citizens' awareness and understanding of what must be done
- Mechanisms for rapidly assessing and reporting of infrastructure relief and recovery needs. This may include the use of satellite imagery
- The emergency plans and plans derived from the policy recommendations are to exercised periodically and updated appropriately to ensure the required level of quality, robustness and efficiency at all levels just before the commencement of the Hurricane Season.
- If possible, in preparation there should be a rehearsal of the plan nationally

8.3 Pre Disaster Activities

- The emergency plans are to exercised periodically and updated appropriately
- Broadcaster should be required to issue emergency tones and national emergency broadcasts
- Participate in emergency drills done by other key stakeholders and invite involvement in one's own exercises to help build a more cohesive response program.
- Ensure critical spares are available on site and can be retrieved at a moment's notice. Where cost is an issue, establish MOU with broadcast partner or supplier for loan/purchase in emergency.

8.4 Disaster Circumstances

The on-set of a disaster situation will trigger the execution of the disaster plans. Provided that the obligations placed on network operators, broadcasters and HAM operators have

been fulfilled continuous communications services for stakeholders will be available. In the case of extreme circumstances whereby there is catastrophic devastation expedited restoration of services would be anticipated.

8.5 Post Disaster

Execution of mechanisms to assess and report on communications infrastructure relief and recovery needs

9 Discussion and Conclusion

Appendix I: Guiding Principles for CCCR's Analysis

CCCR's analysis and recommendations are grounded in the following principles:

2. Despite the multivariate nature of weather and climate, the lack of undeniable evidence of changes in tropical cyclone behaviour, and variance of opinion (Bender et al (2010)¹¹, Elsner & Jagger (2008)¹², Murakami et al (2012)¹³, Elsner et al (2008)¹⁴, etc.,etc.), a variety of indications suggest the likelihood of more persistent and devastating hurricanes alongside global warming (Mimura et al. 2007¹⁵). On this basis, the CCCR asserts that there is cause for a systemic resilience-centric ethos in the development and operations of critical telecommunications infrastructure in CTU countries.
3. The mean sea level rise, which in the Caribbean matches the global mean of 1.8 ± 0.5 mm/yr over the last 60 years (Palanisamy *et al.*, 2012¹⁶), the considerable ingress of storm surges exclude popular and convenient coastal and low-lying areas as recommended locations for infrastructure bunkers. The planning of such bunkers, which are a key mainstay of network resilience, must consider these factors.

¹¹ Bender, M.A., Knutson, T.R., Tuleya, R.E., Sirutis, J.J., Vecchi, G.A., Garner, S.T., and Held, I.M. (2010) Modeled impact of anthropogenic warming on the frequency of intense Atlantic hurricanes. *Science* 327, 454–458

¹² Elsner, J. and Jagger, T. (2008) United States and Caribbean tropical cyclone activity related to the solar cycle, *Geophys. Res. Lett.*, 35, L18705. doi:10.1029/2008GL034431.

¹³ Murakami, H., Mizuta, R. & Shindo, E. (2012) Future changes in tropical cyclone activity projected by multi-physics and multi-SST ensemble experiments using the 60-km-mesh MRI-AGCM, *Climate Dynamics* 39 (9), 2569-2584. doi:10.1007/s00382-011-1223-x

¹⁴ Elsner, J., Kossin, P., and Jagger, T. (2008) The increasing intensity of the strongest tropical cyclones, *Nature*, 455, 92- 95.

¹⁵ Mimura, N., L. Nurse, R.F. McLean, J. Agard, L. Briguglio, P. Lefale, R. Payet and G. Sem, 2007: Small islands. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 687-716.

¹⁶ Palanisamy, H., Becker, M, Meyssignac, B., Henry, O., and Cazenave, A. (2012) Regional Sea Level Change and Variability in the Caribbean Sea since 1950, *J Geod Sci*, 2(2), 125–133. doi:10.2478/v10156-011-0029-4.

4. The CCCR recognizes that telecommunications is one of a number of critical sectors. This report is offered as the baseline sector-specific reference point for the regional Comprehensive Disaster Management Strategy and Programming framework (CDEMA 2014¹⁷) and for existing and planned national disaster management plans.
5. The CCCR recognizes that weather- and climate-related disasters are not the only phenomena that put telecommunications infrastructure, and by extension public telecommunications services, at risk. Nevertheless, this is an area of vulnerability shared across all sectors and is of particular significance to small island developing states. It provides a ready opportunity for closer integration of the telecommunications sector into regional and national critical infrastructure planning and management.
6. CCCR recommendations are assumed to be treated in the context of prevailing considerations such as other hazards which impose more conservative constraints on placement of infrastructure
7. The inherent resilience of routable networks and the universal evolution of both multiservice and traditional networks to IP, renders packet switching in general and IP in particular the platform of choice for new network builds.
8. The existence of legacy networks in the countries of interest and the competing demands on limited financial and human resources, justify continued support and use, with special attention to resilience-strengthening
9. Disaster and early recovery circumstances call for application of the modularity principle in which any available routable network technology is put to use. Network design must anticipate and provision for this.
10. Ancillary services such as power and environmental control are considered intrinsic to critical communications infrastructure
11. All infrastructure is not critical, neither are all services.

¹⁷ CDEMA. Regional Comprehensive Disaster Management (CDM) Strategy and Programming Framework 2014-2024 (DRAFT). Barbados. 2014. Available at <http://www.cdema.org/CDMStrategy2014-2024.pdf>. Last viewed 24 May 2018

12. The three principles of high availability engineering underpin the recommendations for critical network elements:

- i. Elimination of single points of failure
- ii. Provision of reliable crossover
- iii. Detection of failures as they occur.

13.

14. Targets for critical network facilities are:

- i. Redundancy of N+1 or N+2, depending upon the degree of criticality
- ii. Hot, rather than cold, standby to ensure functionality of equipment and operator/s
- iii. Recovery kits comprise tools and raw materials needed to effect repairs, not spares of operational equipment
- iv. Underground where technically and logistically feasible
- v. Backup power provisioned for five days – after which time we deem that other logistical matters present the bottleneck to recovery.

15. Local circumstances may render target provisioning inappropriate. For example the burying of fiber in landslide zones and river beds.

16.

17. The implementation, operations and recovery of telecommunications networks rely on a number of externalities over which operators have little or no control. Provisioning for network resilience must address these matters alongside those that require action on the part of the operators.

18. The road to resilience is an incremental one, as strategic as it is opportunistic

19. Critical infrastructure is a public good, managed and in many cases owned by private concerns. Reasonable public-private partnerships are required for resilience-proofing

20. There is a cost to resilience.

APPENDIX II: Network Resilience Questionnaire for Policy Makers

Background Information Sought from Policy Makers

A. Policies for Emergency Planning

Do policies for public telecommunications networks and broadcasting systems	Y	N
1. support or encourage the use of alternative or emerging technologies (e.g. LEOs and MEOs) to improve the resilience of communications networks?	<input type="radio"/>	<input type="radio"/>
2. require multi-agency planning for telecommunications services in emergency situations?	<input type="radio"/>	<input type="radio"/>
3. address systems for extra-national communications support in emergency situations?	<input type="radio"/>	<input type="radio"/>
4. encourage or require network infrastructure sharing for expeditious restoration of services?	<input type="radio"/>	<input type="radio"/>
5. address the adequacy of building and installation codes?	<input type="radio"/>	<input type="radio"/>
6. encourage infrastructure sharing amongst telecommunications network service providers?	<input type="radio"/>	<input type="radio"/>
7. encourage multi-sector infrastructure sharing ? (e.g. Electricity and telecommunications providers)	<input type="radio"/>	<input type="radio"/>
8. incorporate access to extra-national communications services into emergency requirements?	<input type="radio"/>	<input type="radio"/>
9. require a formal role for radio amateurs in emergency communications plans?	<input type="radio"/>	<input type="radio"/>
10. take into account recommendations, guidelines , conventions etc. of relevant regional and international organisations regarding emergency communications?	<input type="radio"/>	<input type="radio"/>
11. encourage stakeholders to safely and efficiently dispose of the assets when they have reached the end of their useful life and for the environmentally-friendly decommissioning and disposal of network infrastructure?	<input type="radio"/>	<input type="radio"/>
12. prioritise the allocation of energy resources i.e. gasoline, electricity	<input type="radio"/>	<input type="radio"/>

B. Policies for Service Delivery

21. Do the policies	Y	N
13. support the establishment of common approaches by service provider, responders and end-user to address lifecycle risks associated with the technology infrastructure?	<input type="radio"/>	<input type="radio"/>
14. ensure that the service levels and support are maintained in accordance with the obligations of all governments, regulators, service providers and other stakeholders?	<input type="radio"/>	<input type="radio"/>
15. ensure that network infrastructure that is no longer capable of providing the service levels, under its obligations, will be replaced by service provider and other stakeholders as part of the technology refresh programme?	<input type="radio"/>	<input type="radio"/>
16. support a complete assessment of the costs and resources required to manage assets through the entire technology lifecycle?	<input type="radio"/>	<input type="radio"/>

17. require standards for minimum levels of services	<input type="radio"/>	<input type="radio"/>
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C. Policies for Promoting Co-operation During and Post-Disaster

22. Do the policies	Y	N
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18. Identify the necessary coordination activities for effective emergency communication services and restoration of services?	<input type="radio"/>	<input type="radio"/>
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19. require service providers to share critical information with other service providers, responders and end users to facilitate expeditious restoration in emergency situations?	<input type="radio"/>	<input type="radio"/>
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20. require service providers to communicate, collaborate and cooperate with other service providers and response agencies to restore communications expeditiously?	<input type="radio"/>	<input type="radio"/>
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21. require service providers to share serviceable infrastructure in order to restore service expeditiously?	<input type="radio"/>	<input type="radio"/>
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23.

D. Policies for Fostering Resilience

24. Do the policies	Y	N
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22. ensure that the level and standard of the technology infrastructure, services and service levels, required to support efforts in disaster management campaigns are met continuously and at the required level of quality, robustness and efficiency?	<input type="radio"/>	<input type="radio"/>
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23. support the use of any fund for network resilience and recovery?	<input type="radio"/>	<input type="radio"/>
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25. If yes, name the fund.

24. provide incentives for building resilience into communications networks?	<input type="radio"/>	<input type="radio"/>
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25. require the maintenance of continuously verified, standby access to extra-national communications services for use in emergencies?	<input type="radio"/>	<input type="radio"/>
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26. standards for minimum levels for resilience (e.g. redundancy) for public telecommunications networks and broadcasting systems?	<input type="radio"/>	<input type="radio"/>
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27. Encourage minimum building standards for networks in the Hurricane Belt.		
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E. Policies for Telecommunications Access

26. Do the policies address the need for	Y	N
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28. privileged access to telecommunications services for key stakeholders in emergency situations?	<input type="radio"/>	<input type="radio"/>
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29. special access for persons with disabilities	<input type="radio"/>	<input type="radio"/>
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F. Policies for Volunteers

- | | Y | N |
|--|-----------------------|-----------------------|
| 27. Do policies address | | |
| 30. the work and contribution of volunteers (e.g. HAM Operators) in emergency situations? | <input type="radio"/> | <input type="radio"/> |
| 31. support full integration of such operators in the multi-agency cooperation framework for emergency situations? | <input type="radio"/> | <input type="radio"/> |
| 28. | | |

G. Recommendations

- | Are these policy recommendations are reasonable? | Y | N |
|--|-----------------------|-----------------------|
| 28. All sectors maintain GIS infrastructure databases which support import from, and export to, all other sector databases; infrastructure projects in each sector required to submit layer/s into a GIS database of the relevant regulator; national resilience database draws on and expands these layers (critical sites and infrastructure, assets, etc...) managed by the disaster management authority | <input type="radio"/> | <input type="radio"/> |
| 29. Open data policy for ICT infrastructure, specifying exclusions on the basis of national security | <input type="radio"/> | <input type="radio"/> |
| 30. Requirements for back up of critical data at multiple sites including other countries | <input type="radio"/> | <input type="radio"/> |
| 31. Establishment of a community of competent ICT persons available to assist in times of disaster | <input type="radio"/> | <input type="radio"/> |

H. Other Recommendations

29. Please share your recommendations for policies to improve the resilience of Caribbean communications networks.

I. Response to the 2017 Hurricane Season

What proactive steps were advocated by your Ministry in preparation for the hurricane season?

What strategies, if any, were used by your Ministry for dealing with the unfolding devastation?

What role, if any, does the Regulatory Authority play during the recovery period?

APPENDIX III: Background Information Sought from Regulators

1. Do you require that operators provide coordinates (longitude and latitude) at which they will place their infrastructure (towers, POPs, landing sites, landing stations etc)?
 - i. If so, where are these requirements stated (application form for license, concessions, licenses, other)?
2. Do you maintain a database of infrastructure (towers, POPs, landing sites, landing stations etc)?
 - i. If so, is this data georeferenced (i.e. each item associated with longitude and latitude?)
 - ii. If so, does the NTRC have the capability to visualize the infrastructure on a GIS map?
3. Are you authorised in law to set standards for, and enforce, minimum levels of resilience (e.g. redundancy) for public telecommunications networks and broadcasting systems?
 - i. If yes, have standards been established in the regulations?
 - ii. Are these standards being monitored? Met?
 - iii. If no, are there any plans to establish such standards?
4. Is there radio frequency spectrum exclusively reserved or allotted for use by public health and safety, disaster management agencies or PPDR applications?
 - i. If yes, please specify allocations in all bands and indicate whether this spectrum is utilised
 - ii. If 694 – 894 MHz has not been allocated for broadband PPDR, is there a plan to do so?
5. How many amateur radio operators are licensed in your administration?
6. Were amateur radio bands congested during 2017 hurricanes or other times of disaster?
7. Are there any frameworks that dictate how amateur radio operators are engaged and operate in emergency situations? If not, should there be one?
8. Please identify all mobile radio (LMR, MMR) bands in your national frequency allocation table (FAT).
 - i. Were these bands congested during 2017 hurricanes or other times of disaster?

- ii. Are all these bands made available to national security and other first responder agencies during times of disaster?
9. Roughly what percentage of the country (geography) is covered by land mobile radio?
10. Are there frequency allocations and rules to allow the use of TVWS?
- If not, can you share the reason/s for not having provisions for TVWS?
11. How many subsea (submarine) cable systems are landed in the country?
12. How many landing points are there?
13. Please indicate the number of cable systems per landing point
14. Are there plans to construct a national fibre backbone apart from the existing fibre plant of operators?
15. Are there plans or proposals for the creation of an independent emergency telecommunications network in the BVI?
16. Does your telecoms Act enable use of public telecommunications networks for national security under emergency conditions? If so, please provide the extract.
17. Are facilities sharing regulations in place?
- If no, are there plans to implement facilities sharing regulations?
18. Are there cable restoration and mutual aid agreements in place?
- i. During past hurricanes, in particular in 2017, was cable restoration timely?
 - ii. If not, what were the bottlenecks to restoring cable?
19. Are there any towercos (tower companies)? Would there likely be interest in the use of towercos for new tower builds?
20. Is there a national emergency communications plan in effect? If so, may we have a copy please?
- If not:
- i. Have you been asked to participate in the development of a national emergency communications plan?
 - ii. Do you think that a national emergency communications plan should be developed?
 - iii. Do you think that the regulator should participate in the development of a national emergency communications plan?

21. Do you have a fund to assist in promoting network resilience in public telecommunications networks and broadcasting systems?
22. Do you have a universal service fund (USF)? If so, can your USF be used for network resilience or recovery?

If no, are there plans to introduce a USF?

Please discuss whether these recommendations are reasonable in your view:

- iii. where necessary, amendment of existing broadcast licenses for, and introduction into all new licenses of, mandatory requirements for public, private and foreign-owned broadcasters, including subscription services, to issue emergency tones/ national emergency broadcasts etc.
 - iv. disaster resilience audits and preparation of business continuity plans for public broadcasters
 - v. Are there provisions in law to permit duty-free import of equipment required for emergency telecommunications or broadcasting services – whether prior to or after a disaster event?
 - vi. CDEMA RNATs (Rapid Needs Assessment Team) to include assessment of communications infrastructure relief and recovery needs
23. Please share your recommendations to improve the resilience of Caribbean communications infrastructure.