Emergency Communications Policies in Puerto Rico: Interaction between Regulatory Institutions and Telecommunications Companies during Hurricane Maria

ABSTRACT

Extreme infrastructure collapse poses unique challenges to emergency communications. This was the case in Puerto Rico in 2017 after hurricanes Irma and Maria. In this study, we first examined telecommunications carriers representatives' views of the adequateness of emergency communications policies. Their views were constrasted with a selection of telecommunications experts and regulators' views. Secondly, we conducted a policy analysis to assess the FCC, the Telecommunications Bureau of Puerto Rico, and telecommunications companies' emergency communications processes and outcomes. An electronic questionnaire and in-depth interviews with telecommunications companies' representatives, and secondary data analysis were used. The analysis revealed that the most participants didn't consider favorably emergency communications polices at the federal level. Similarly, most considered state level policies as not adequate. The policy analysis points to ineffective federal and state emergency communications policies due to the impact external factors and the lack of coordination of the state government electrical power provider and private telecommunications companies. The results also revealed that between 2017 and 2019 policymaking and policy tools application in regard to emergency communications were largely reactive and relying on a vigorous state level intervention in the telecommunications industry, as opposed to primarily regulating it. The analysis includes policy recommendations for emergency communications.

1. Introduction

Natural and human-made disasters validate the social importance of traditional news media, new media, and emergency warning systems. Extreme infrastructure collapse poses unique challenges to emergency communications. This was the case in the Commonwealth of Puerto Rico in 2017 after hurricanes Irma and Maria battered the island and left its citizens without access to communication channels and emergency communication services. This study examines emergency communications policies carried out by the Federal Communications Commission (FCC), the Telecommunications Bureau of Puerto Rico (TBPR), and Privately-Owned Telecommunications Companies (PTCs) during Hurricane Maria response and recovery phases.

Federal and state laws and rules adopted or enforced by the FCC and the TBPR[1] — the regulatory agencies for telecommunications services in Puerto Rico — serve to define roles and emergency communications policy objectives. These objectives are adopted by different policy actors such as public safety organizations, regulatory institutions, citizenry and PTCs. During emergency situations, PTCs (e.g. wireline carriers, wireless carriers, broadband services companies, telecommunications infrastructure companies) rely upon a combination of legal mandates, policy tools (e.g. technical standards, licensing, subsidies, tax credits) and industry self-regulatory standards (e.g. best practices, codes) and agreements (e.g. cooperative frameworks). Also, PTCs' activities are integrated to federal, state, municipal governments, private organizations (non-governmental organizations), and volunteers emergency response activities. In

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[1] On August 12, 2018 the Act to Execute the Reorganization Plan of the Puerto Rico Public Service Regulatory Board (Law Num. 211) was signed into law. The law created the Puerto Rico Public Service Regulatory Board (PRPSB). The law renamed the Puerto Rico Telecommunications Regulatory Board (PRTRB) to the Telecommunications Bureau of Puerto Rico. With the exception of the resolutions and orders the study will refer to the state telecommunications regulator as the Telecommunications Bureau of Puerto Rico (TBPR).

particular, PTCs' conduct is aimed at providing continuity of emergency communications services for public safety services (e.g. 991 emergency services) and commercial services to citizens (e.g. wireline and wireless telephony).

This study of emergency communications policies in Puerto Rico is articulated at two levels of analysis. First, adopting a stakeholder approach, we analyze PTCs' (i.e. Carriers, Broadband & Network Services, Communications Infrastructure) views in regard to the adequateness and need to strengthen emergency communications regulatory policies. Their views were constrasted with a selection of five interviews with state level telecommunications experts and regulatory officials. This second group of interviews contributed to the analysis providing a better understanding of the regulatory framework for emergency communications in Puerto Rico, but their responses are not included in the results. Therefore, the study only analyzes carriers' perspectives. Secondly, a policy examination of FCC, TBPR and PTCs' interaction and outcomes through a detailed analysis of the emergency management activities and adoption of policy tools during the emergency situation in 2017.

The analysis is conceptually grounded in policy studies and media and telecommunications policy analysis. Since the study focused on PTCs' opinions, this study followed an inductive and exploratory approach but grounded in an analytical framework proposed by Picard and Pickard (2017) for media and telecommunications policy making and policy analysis. This framework served as the starting point for the analysis of PTCs' opinions about emergency communications policies, and the analysis of the organizations' conduct during the response and recovery phases. The policy problem explored is the extent to which emergency communications policies carried out in Puerto Rico provided citizens and public safety authorities effective use of emergency communications services during the response and recovery phases. The policy problem is framed

in three types of relationships and influences: 1) FCC and telecommunications industry interaction, 2) TBPR and telecommunications industry interaction, and 3) Wireless industry self-regulatory practices during emergency situations, specifically the roaming service agreement in 2017.

This study also presents a detailed narrative of the diverse, overlapping, and complimentary federal and state emergency communications policies at play after Hurricane Maria in Puerto Rico. The analysis of governmental literature and other documentation, embedded within the accounts of companies' representatives, provide a unique in-depth view of emergency communications policy processes. Our purpose is to contribute to the academic research examining contexts of extreme infrastructure collapse in relation to emergency communications policy objectives, policy mechanisms, and policy tools. In addition, we draw from the participants' in-depth interviews to present practical recommendations (as suggested by Enserink, Koppenjan & Mayer, 2013) for telecommunications at the federal and state levels that could be implemented to strengthen emergency communications in Puerto Rico and other contexts.

2. Conceptual considerations of emergency communications policies

2.1 Policy Analysis and Telecommunications Policy

The literature on policy analysis for public policymaking shows that changes in the legal sphere as well as technological innovation have been two significant factors in the evolution of emergency communications regulatory policies. First, telephone companies have to provide access to local public safety emergency systems such as 911 and E911 (Nuechterlein & Weiser 2007; Ten, 2001). Also, Ryan and Peha (2008) recommended the deployment of a single nationwide network that serves all public safety personnel, and Peha (2009) analyzed long-term spectrum policy reform in relation to public safety spectrum. Moreover, given the wide adoption of wireless communication

services, Seeman, Kleckley and Holloway (2018) analyzed the policies to implement and fund the transition from Enhanced 911 to Next Generation 911 (NG911) and its integration to the Nationwide Public Safety Broadband Network.

Several scholars have addressed some of the challenges for media and communications policy analysis. For instance, Napoli (1999) elaborated on the unique traits of media regulation in relation to other industries regulatory regimes and proposed a symmetrical approach to communications policymaking. For Napoli, policy makers should base their decisions on analytical assessments that take into account economic and social values for policy objectives in an equitable way.

Another perspective within a framework based on legal principles has been proposed to address how economic viability and political feasibility limit the adoption of sustainable policy options for telecommunications regulation (Cherry, 2006). Cherry pointed out a trend in academic research on the relationship of deregulatory policies and the design of regulatory incentives to affect the behavior of private parties in order to achieve expected policy goals. More recently, Picard (2020) addressed the historical evolution and the normative topics for media, information and telecommunications policies. Picard examined different policy methods and tools (e.g. government intervention, regulation, policy mechanisms) in relation to media and communications policy analysis.

Picard & Pickard (2017) proposed a framework based for media and telecommunications policy making and policy analysis based on seven principles. The framework serves to "inform the development of policy objectives and policy mechanisms and to provide consistency across varying issues, technologies, and actions by defining fundamental criteria that can be used to inform discussion and guide policy decisions" (p.5). Their attention was on defining fundamental

principles from which specific policies objectives, policy tools, and desired outcomes can be originated. For Picard and Pickard (2017, p.5), policy analysis for policymakers, policy advocates and scholars should start from "a more principled level and then link policy objectives and tools to these normative foundations rather than merely seeking immediate problem solutions." These principles for media and communications policymaking and policy analysis are:

1) Meeting fundamental communication and content needs;
2) Providing effective ability for public use of media and communications;
3) Promoting diversity/plurality in ownership of media and content available;
4) Affording protection for users and society;
5) Providing transparency and accountability;
6) Pursuing developmental and economic benefits; and
7) Pursuing equitable and effective policy outcomes.

Picard & Pickard (2017) argue that the main stakeholders in emergency communications are the citizenry and authorities (e.g. first responders), and during emergency situations the primary objectives of communications are: 1) Allow the public to communicate with authorities and among themselves, and 2) Allow authorities to communicate directly to the public and to enhance communication among authorities themselves. In this study we used these two principles as conceptual lenses for a policy examination of emergency communications processes and outcomes during the response and recovery phases in Puerto Rico. The lack of existing theoretical models or frameworks for emergency communication policy analysis requires an exploratory and inductive approach that allows for the development of emergency communications performance analysis instruments.

2.2. Law, Regulation, and Self-regulation

The legal and regulatory literature distinguishes federal and state provisions for public safety communication services, and those emergency communications requirements specific for PTCs. In this section we'll refer to federal and state laws and rules for emergency communications that

make up a dynamic framework that sets different types of requirements, either mandatory or voluntary to Public Safety Organizations and PTC's.

The FCC's definition of emergency communications details roles and services related to the 911/E911 Service, the Emergency Alert System, Commercial Mobile Alert System, Emergency Management Information Systems (e.g. Disaster Information Reporting System, Network Outage Reporting System) and spectrum interoperability for public safety systems.[2] The Communications Act of 1934 sets the principle of universal service, that is, telephone access to all citizens (Jayakar, 2009) and eligible telecommunications carriers (ETCs) receiving Universal Service low-income support are required to meet emergency communications provisions. According to the federal requirement on 47 CFR 54, Subpart-C-Carriers Eligible for Universal Service Support, 54.202 (a)(2), a company must:

> Demonstrate its ability to remain functional in emergency situations, including a demonstration that it has a reasonable amount of back-up power to ensure functionality   without an external power source, it's able to reroute traffic around damaged facilities, and is capable of managing traffic spikes resulting from emergency situations.[3]

At the state level, Telecommunications Law 213 - 1996, created the Puerto Rico Telecommunications Regulatory Board (PRTRB) and reaffirmed the Universal Service principle of the Telecommunications Act of 1996. As in the federal statue, state law provided for eligible telecommunications carriers could receive subsidies through the Puerto Rico Universal Service

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[2] FCC. Emergency Communications. Retrieved from: https://www.fcc.gov/general/emergency-communications.
[3] 47 CFR 12. PS Docket No. 14-174. FCC 15-98. See also FCC. (2015). Ensuring Continuity of 911 Communications.

Fund (a complimentary fund) to provide acces to telecommunications services to vulnerable groups and low income households (e.g. Lifeline Program and Link-Up America Program).[4]

The TBPR requires telecommunications companies to demonstrate the ability to deal with emergency situations. The *Reglamento para la Expedición de Certificaciones y Franquicias* (Regulations for the Issuance of Certifications and Franchises) and the *Reglamento de Servicio Universal* (Regulations for Universal Service) also set the legal and procedural basis for the state regulator to certify ETCs every two years and formulate new requirements related to the ability of companies to continue providing services during emergency situations. Also, Article 2 of Chapter III of Law 213-1996 provides that companies must demonstrate "moral and economic solvency, their experience or history in the area in which they request certification". Therefore, the regulatory regime at the federal and state set on telecommunications carriers and PTC's the responsibility and ability to restore telecommunication services to consumers during emergency situations (e.g. capacity to provide continuity of services, reroute traffic, networks interconnection and interoperability).[5]

As noted by Picard and Pickard (2017), self-regulation is a topic of growing importance for international and industry professional organizations, telecommunication companies and media and communications policymaking organizations.[6] Emergency communications intra-industry standards (e.g. best practices, codes) and agreements (e.g. cooperative frameworks) for emergency situations are important self-regulatory provisions.[7] In 2016 the Wireless Resiliency Cooperative Framework adopted by U.S. wireless carriers and industry associations, endorsed by the FCC, was

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[4] Telecommunications Act of 1996, Section 254(b) and the Puerto Rico Telecommunications Law 213 -1996, Statement of Reasons.
[5] See Article 9.3 in PRTRB, Regulations for Universal Service.
[6] See International Telecommunications Union. (2020). ITU Guidelines for national emergency telecommunication plans; The World Bank/GFDDR. "Communication during Disaster Recovery. Disaster Recovery Guidance Series".
[7] Cited in Picard and Pickard, Haufler, V. (2001). *A Public Role for the Private Sector: Industry Self-Regulation in a Global Economy*. Washington, DC: Carnegie Endowment for World Peace.

the basis for an important, if not historic agreement and collaboration between wireless carriers in Puerto Rico, later endorsed by the TBPR. This agreement's main outcome was that that it provided roaming service to wireless subscribers during the recovery phase. This cooperative initiative fits under what Freeman refers to as business and top-down approaches to crisis informatics, in which "an overarching policy effort (e.g., national) is used to assist and make decisions of how the technology can be used by citizens" (Freeman, 2011, p.74).

2.3 Emergency communications framework

In natural disasters, acts of terrorism, and other man-made disasters, the Homeland Security Act of 2002 (6 USC 101 et seq.), identifies communications networks as a critical infrastructure. During emergency situations communications networks response and recovery activities are led by the Department of Homeland Security (DHS). DHS have designated a group of agencies that provide communications support to state, local, tribal, and territorial (SLTT) governments, agencies and first responders "when their systems have been impacted and provides communications and information technology (IT) support to the Joint Field Office (JFO) and JFO field teams."[8] The FCC and the TBPR are Emergency Support Function #2 (ESF#2) organizations with specific emergency plans[9] and calls to action.[10] Under these considerations, first responders' organizations and citizenry are the main subjects of a dynamic emergency communication model

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[8] DHS. (2016). National Response Framework (3rd ed); NRF. (2008), Emergency Support Function Annexes: Introduction.

[9] As an ESF#2 organization the TBPR during an emergency situation supports the restoration of communications infrastructure and services and in the coordination between PTC's and federal, state, and local public safety organizations. See Torres López, S. E. (2017, December 7). Letter to Hon. Miguel A. Laureano Correa. President, Innovation, Telecommunications, Urban and Infrastructure Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 457).

[10] DHS. (2008). National Emergency Communications Plan. P.11; DHS. (2013). NIPP 2013. Partnering for Critical Infrastructure Security and Resilience. P. 21-25; Torres López, S. E. (2018, May 25). Letter to Hon. Henry Neumann Zayas, President, Public Safety Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 708).

that entails various emergency warning systems (e.g. Emergency Alert System, Wireless Emergency Alerts/Commercial Mobile Service Alerts, and the Integrated Public Alert & Warning System), emergency management information systems (e.g. Disaster Information Reporting System, Network Outage Reporting System), use of multiple technologies (e.g. wireless services, broadcasting services) and a dedicated segment of the electromagnetic spectrum to provide access to emergency communications services.

At the state level, since 1999 the TBPR have had a dual role in emergency communications. First, is the coordinator of the communications component in the Puerto Rico Agency for Emergency and Disaster Management (PRAEDM). Over the following years, the TBPR's mission was to provide assistance for the continuity of public communications services in PRAEDM and over a dozen other state agencies. This role includes providing support in the coordination of federal, state, and local communications during emergency situations. Secondly, in 1999 the TBPR created the Emergency Management Program. This program is based on a cooperation agreement between the state regulator and Eligible Telecommunications Companies (ETCs). The agreement was the foundation for the creation of the Committee of the Telecommunications Industry for Emergency Management (CTIME). The committee's main objective is to restore and protect the telecommunications and cable television infrastructure, as well as to be responsive to the communications needs that arise from emergency or disaster situations (Rosario-Albert, 2016).

3. Background to Emergency Communications in Puerto Rico

In this study we examine emergency communications policies in Puerto Rico around the time of Hurricane Maria because of the uniqueness of the case, one in which the telecommunications infrastructure entirely collapsed. In this section we provide an overview of the telecommunications

sector including access and adoption rates of main electronic media and telephone services, and economic and historical trends.

In 2017, Puerto Rico's telecommunications industry profile showed that in the wireline sector, Claro/Puerto Rico Telephone Company (Claro/PRTC) was the Incumbent Local Exchange Carrier, and together with AT&T, Liberty of Puerto Rico, T-Mobile, Sprint, and Open Mobile were the other Competitive Local Exchange Carriers. By then, Liberty of Puerto Rico was the only cable television service, which also provided telephony (VoIP) and Internet services. Up until 2017, the telecommunications industry revenues showed gains from 2011 ($2,329,985,690) to 2016 ($2,269,116,256). In 2017, the year of Hurricanes Irma and Maria, the telecommunications industry revenues ($1,912,882,859) decreased 16%.[11]

In 2017 mobile subscription per 100 inhabitants reached 107.04% but individuals using the Internet was 70.60 % of the population.[12] Mobile telephony accounted for 3,89,402 lines (81%) of all telephone lines, while wireline telephony accounted for 783,739 lines (19%). In 2017 the consolidated total (4,173,141) of wireline and wireless lines as well as for total broadband subscribers (3,372,768) had reached a peak year. Another indicator is the number of low-income customers (556,455) subscribed to the Lifeline Program in relation to the consolidated total of lines for 2017.[13] By the time of Hurricane Maria, 13% of the consolidated total (wireline and wireless) were low income subscribers (a vulnerable group). Being 2017 a year of record growth in broadband subscribers and in wireless services, which are provided by PTCs, makes the analysis

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[11] Puerto Rico Telecommunications Bureau. (2020). Statistics for Telecommunications and Cable Television Industries in Puerto Rico.

[12] ITU. (2020). *Mobile-Cellular Subscriptions*; Puerto Rico Telecommunications Bureau. (2020). *Statistics for Telecommunications and Cable Television Industries in Puerto Rico*.

[13] The Lifeline Program was established in 1985. The FSU has two items: one item is to company infrastructure and the other item is for the Lifeline grant program, which is a telephone subsidy for low income families.

of emergency communications policies in Puerto Rico more relevant and may provide data for other emergency communication policies reviews.

The analysis of emergency communications polices in Puerto Rico also considers economic and infrastructure historical trends. First, in 2015 the state government credit classification had been progressively degraded and in 2016, for the first time in its history, a Federal District Court decided that the island's government was insolvent and unable to pay its obligations deepening the political, social and economic crisis. In 2017 the poverty rate was 44.4% and unemployment rate had reached 10.8%.[14]

The second consideration was the devastation of already degraded electric power infrastructure. As the Government Accountability Office (2017) pointed out, wireline and wireless networks are dependent on external and commercial electrical power companies to provide uninterrupted telecommunications services. Also, to provide wireless services to consumers, wireless carriers networks interconnect to wireline networks (e.g. local telephone company or cable company). Hence, power failures in wireline services can create outages in the backhaul network, affecting wireless networks. In relation to backup power at cell sites, a GAO report stated that in 2007 the FCC had set for wireless carriers a requirement of eight hours of backup power. However, the Office of Management and Budget disapproved FCC's requirement because of the rule's information collection requirements, having the effect of withdrawing the rule.[15]

Miller, Chester, and Muñoz-Erickson (2018) analyzed the destruction and inability of the Puerto Rico Electric Power Authority (PREPA) to restore electricity production and distribution

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[14] US Census Bureau. *More Puerto Ricans move to Mainland United States, Poverty Declines*. (September 26, 2019); Center for Economic and Policy Research. (2017). *Life After Debt in Puerto Rico: How Many More Lost Decades?*

[15] The report affirmed that nine of the stakeholders interviewed for their study were open "about the feasibility of guidance". See U.S. Government Accountability Office. (2017). FCC Should Improve Monitoring of Industry Efforts to Strengthen Wireless Network Resiliency. DC: GAO. P. p.6-7, 31.

after Hurricane Maria, becoming the largest power outage in US history. The collapse of the electrical network had a cascade effect on public safety services (e.g. 911 emergency service and first responders' activities, access to healthcare, nutrition and housing services) and in wireless telephony resulting in approximately over three million wireless lines out of service for weeks during the emergency situation. Access and adoption to wireless telephony services is paramount to assess the effectiveness of plans to restore telecommunications services to citizens and its use by news organizations (Nieves-Pizarro, Takahashi, & Chavez, 2018; Takahashi, Zhang, & Chavez, 2019).

The considerations above serve to contextualize the process to restore emergency communications services, particularly in wireless telephony. As stated by the FCC, in Puerto Rico "Wireless service was restored gradually over a six-month period, considerably longer than for any other storm."[16] The combination of the historical trends in the economy and in the electrical power infrastructure, together to Hurricanes Irma and Maria devastation, meant from the outset unique challenges to public safety organizations and PTCs' readiness and capacity to restore emergency communications.

Based on the discussion above, we pose the following research questions:

RQ1 In what ways and to what extent did federal regulations facilitate the deployment of emergency communication services?

RQ2 In what ways and to what extent did state regulations facilitate the deployment of emergency communication services?

RQ3 What external and structural factors were more influential in the reestablishment of emergency communications?

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[16] FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations. Public Safety Docket No. 17-344. p.15.

4. Methods

The study integrates two approaches. First, we conducted an analysis of Private Telecommunications Companies' opinions using the following methods: 1) an electronic questionnaire; 2) semi-structured in-depth interviews; and 3) institutional documentation from federal and state agencies, the local and national press, and academic studies.

Secondly, a policy examination was conducted focusing on the FCC, TBPR and PTCs' emergency communications processes and outcomes during Hurricane Maria response and recovery phases. The research used a qualitative approach supported by the analysis of data originated mainly from regulatory agencies. This provided a granular look at the implementation of regulatory policies for emergency communications.

4.1 Interview and questionnarie data collection and analysis

A purposive sampling approach was used to select a group of eligible telecommunications companies (ETC) certified by the TBPR. After Hurricane Maria, and for the next 60 days, the TBPR organized daily meetings with representatives of both telecommunications and telecommunications infrastructure companies. During the process to reestablish telecommunications services, 15 telecommunications service companies participated in the meetings at the Emergency Operations Center (EOC) of the Government of Puerto Rico (GPR). To facilitate the participation of these companies in the study, we used a list with the companies' contact details that the TBPR provided. E-mail invitations were sent to the 15 companies and follow-up calls were made to explain the purpose of the research project.

The qualitative analysis is based on the answers to the electronic questionnaire and in-depth interviews. Eight of the 15 companies responded to the electronic questionnaire (Table 2). The

response rate to the electronic questionnaire was 53%. The questionnaire used closed and multiple-choice questions that reflected the research questions to gather the opinions and different emphasis of PTCs.

Table 2: Companies that answered the electronic questionnaire

Companies	Services
AeroNet	- Broadband & Network Services
Crown Castle	- Communications Infrastructure
DatAccess	- Broadband & Network Services
Liberty Cablevision of Puerto Rico LLC.	- Carrier, Cable TV, Telephony, Broadband Services
PREPA Networks	- Network Infrastructure
Verizon	- Network Infrastructure
VPnet	- Broadband & Network Services
WorldNet Telecommunications, Inc.	- Broadband & Network Services

The PTCs that participated in the in-depth interviews include all companies listed in Table 2 plus Neptuno Networks (Broadband & Network Services) and T-Mobile Puerto Rico (Wireless Carrier). Ten interviews were conducted, and two interviews included more than one participant for a total of 13 participants. The response rate for the in-depth interviews was 67%. Of the interviews, eight were conducted in Spanish and two in English. The audio files of the interviews were transcribed verbatim by professional transcribers. Transcripts in Spanish were analyzed directly, with only quotes used in the results section translated to English by the authors. The list of the de-identified information of the interviewees appears in Appendix 1. The participants' PTCs represent different industry sectors (e.g. broadband providers, cable tv providers, network infrastructure, network services and wireless telephony) providing an outlook on the opinions for emergency communications in Puerto Rico. Most of them are members of the Puerto Rican Alliance for Telecommunications (PRTA), an industry organization that represents eligible telecommunications companies in Puerto Rico

In-depth interviews followed a semi-structured approach using open-ended questions based on the research questions and organized thematically and temporarily (before and after September 17, 2017, three days before the hurricane made landfall in Puerto Rico). The qualitative data analysis application *Deedose* was used to analyze interview transcripts. The answers and content obtained were coded according to the research questions, the three subjects (i.e. FCC, TBPR and PTCs) and relationships analyzed, and factors that influenced restoring emergency communications services (e.g. infrastructure, regulatory, logistical). The analysis of the interviews focused on identifying themes related to emergency communications and other emerging and complementary themes directly related to the research questions. Due to respondents' availability, data collection was conducted during two time periods: May to December 2019 (nine participants) and February 2020 (one participant). The data collected from the anwers to the electronic questionnaire and the in-depth reserch interviews from telecommunications carriers (T-Mobile Puerto Rico, Liberty of Puerto Rico) is a limited representation of the total elegible telecommunications carriers at the time of Hurricaine Maria. The data from the remaining PTCs (8), and that actively participated during the rehabilitation of telecommunications services, provide a more representatite account of their point of views on the research questions. In addition to interviews with PTCs, five interviews were conducted with state telecommunications experts (1) and regulatory officials (4) between May and September of 2019. This second group of interviews contributed to a better understanding of the regulatory framework for emergency communications in Puerto Rico, but their responses are not included in the electronic survey results.

4.2 Policy examination: Data collection and analysis

In regard to emergency communications during the response and recovery phases after Hurricane Maria, the FCC and the TBPR were the two government agencies with the responsibility to assist

in the restoration of communication and telecommunications services. These organizations interacted primarily with PTCs and public safety organizations. Therefore, our analysis takes into account the activities of the FCC's Public Safety and Homeland Security Bureau (PSHSB) and the TBPR's Committee of the Telecommunications Industry for Emergency Management (CTIME). To provide a comprehensive assessment of the FCC, TBPR and PTC's activities, secondary data analysis results are organized under two rubrics: Emergency Management Activities (e.g. daily emergency incident reports, fact-finding visits, interagency committees), and Adoption of Policy Tools (e.g. resolutions and orders, thematic reports, stakeholder consultations, legislative hearings).

The study used secondary research sources (e.g. government documents) for two objectives: 1) To synthetize and assess FCC, TBPR and PTC's emergency communications processes and outcomes during the response and recovery phases, and 2) To triangulate the answers to the research questions providing a deeper and multifactorial understanding to the respondents opinions about the feasibility to strengthen emergency communications policies in Puerto Rico.

The research examined federal and state institutional documentation published by the Department of Homeland Security, Government Accountability Office (GAO), and the Government of Puerto Rico.[17] In particular, the review included documents and statistical and economic data published by the FCC and TBPR.[18] Also, we considered reports and journalistic

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[17] U.S. Government Accountability Office. (2018). *2017* Hurricanes and Wildfires. Initial Observations on The Federal Response and Key Recovery Challenges. DC: GAO; Puerto Rico Emergency Management Bureau, Puerto Rico Department of Public Safety. (2019). Joint Operational Catastrophic Incident Plan of Puerto Rico (Version 1.10); Resilient Puerto Rico Advisory Commission. (2018). Reimagina Puerto Rico Informe Sectorial de Infraestructura Física. San Juan PR.

[18] In regard to Hurricane Maria and Puerto Rico, the FCC published Public Notices (16); news releases, statements and presentations (12); reports (1); and communications status reports (107). On the other hand, between September 18 and December 28, 2017, the TBPR issued 74 resolutions and orders, as well as participated in legislative hearings

accounts on the social and economic effects after the passage of hurricanes Irma and Maria in Puerto Rico, carried out by international organizations (e.g. World Meteorological Organization), non-governmental organizations (e.g. Resilient Puerto Rico Advisory Commission), research centers (Center for New Economy), and journalistic organizations (e.g. Centro de Periodismo Investigativo, El Nuevo Día, Free Press).

The second analysis focuses on three types of relationships between regulatory organizations and PTCs during the aftermath of Hurricane Maria: 1) FCC and

telecommunications industry interaction, 2) TBPR and telecommunications industry interaction, and 3) Industry self-regulatory practices during emergency situations, specifically the roaming service agreement in 2017.

5. Results and discussion

The results section first presents a short summary of responses from PCTs representatives to the preliminary closed-ended questionnaire and follow-up interviews that sought to establish the position of the companies on the topic of federal and state emergency communications policies. The second part of this section presents a more detailed account of the emerging themes related to those questions that were extracted from the interviews and supported by the analysis of secondary data.

The results show that half of the companies considered the federal regulation for emergency communications inadequate.[19] A participant considered necessary to improve control and access to telecommunications infrastructure. The participant commented: "Federal entities

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(6) of the State Legislature on issues related to the vulnerabilities of the telecommunications industry and public safety communication systems after the passage of hurricanes Irma and María.

[19] Fitzpatrick, L., Scurato, C., & Torres, J. (2019). Connecting the dots. The telecommunications crisis in Puerto Rico. Free Press.

seemed to take over jurisdiction over private tower owners and block access to certain facilities as they pleased and take control of private property as they pleased without providing proper documentation."[20] Another participant expressed that regulation must consider employees of telecommunications companies as a priority group that support access "to infrastructure services that allow for a faster and more effective recovery".[21]

Second, representatives of four companies disagreed or strongly disagreed about the need to strengthen federal regulation. Several telecommunications companies expressed that it was not necessary to strengthen regulation but to improve the application of administrative procedures and the distribution of detailed information of contacts with the Federal Government. In this sense, a participant said, "I don't think it is a matter of the regulations but a matter of well documented and agreed upon procedures."[22]

Third, most of the responses (n=5) expressed disagreement with state regulation for emergency communications. One participant said: "What I believe was missing was the communication from all government agencies towards the telecom providers. We had to extract information from them." Another participant stated: "I mean if there was regulation and cooperation and a good plan, I think, communications could have been up weeks before it was."[23]

Fourth, representatives of four companies favored strengthening state regulation. Several respondents indicated the importance of communication and coordination for the state government to facilitate and accelerate the processing of permits during the response and recovery phase. Regarding cooperation and emergency communications, one participant stated that "regulation needs to be strengthened in the area of company cooperation…These types of situation are exactly

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[20] Interview #2 with Senior Executive.
[21] Interview #9 with Senior Executives (2 participants).
[22] Interview #10 with Executive.
[23] Interview #7 with Senior Executives (3 participants).

where government needs to regulate, when market forces work against the safety of society".[24]

Another participant provided a singular view on the need to strengthen state emergency communications regulatory policies. For instance, the viability of a non-governmental organization responsible for the emergency communications services. On this matter the participant said:

> I think the hardest part of that was who manages the network. You don't want the government managing it. It's going to be inefficient...But then who is? And maybe the answer is, you know, you got to get the board **(sic. TBPR)** hire as an external party independent to manage it because it's got to be fair and equal for everybody to get access.[25]

The remaining remarks from the results and discussion section are organized in six subsections. The first two sections derived mostly inductively from the interview data. The first subsection addresses telecommunications infrastructure damages, while the second sub-section discusses the factors that influenced the effective use of emergency communications. References to press articles and government documentation are used to develop and support various themes. The next three sub-sections entail the policy examination on the the interaction of the FCC and TBPR with PTCs, and the roaming service agreement, as an industry self-regulatory practice adopted in Puerto Rico during the emergency situation. The last sub-section provides an analysis of recent Emergency Communications State Regulatory Reform.

5.1 Telecommunications infrastructure and services after Hurricane Maria

The analysis of damages to emergency communications associated with Hurricane Maria shows the complex process to restore emergency communications services. For instance, the Weather

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[24] Interview #7 with Senior Executives (3 participants).
[25] Interview with Senior Executive #10.

Radar of the National Oceanic Graphic Administration was destroyed.[26] The FCC reported that the two call centers in Puerto Rico, managed by the Government of Puerto Rico (GPR) were out of service for a period of time or "could not receive the types of information (location, call back number, etc., as happened in both Puerto Rico and the US Virgin Islands (USVI)) that both they and the American public have come to expect."[27]

In regard to Public Safety Systems, restoring the 911 service required technical assistance from the Department of Defense's Joint Force Land Component Command. For instance, the Air Force 85th Engineering and Installation Squadron was deployed to restore radio communications for local emergency personnel and first responders across the island. This account provides information related to the resiliency of public safety networks, as the following remark shows: "What most would consider a redundant communication system in the [mainland] United States, they don't have here…As soon as we get that back up, I think it will definitely help that level of communication."[28] During the in-depth interviews public safety communication systems' resiliency was also addressed. In regard to compliance with federal government standards, a state regulatory official stated:

> And what happens is that each agency chooses …the one that it's going to provide service and most of the time those systems do not talk to each other ... that explains a lot of what happened in the hurricane...At the time of the event, some government agencies did not meet the P25 standard of government emergency management organizations.[29]

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[26] World Meteorological Organization. (2018). Caribbean 2017 Hurricane Season an Evidence-Based Assessment of the Early Warning System. Geneva, Switzerland. P.19.

[27] FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations. Public Safety Docket No. 17-344. P.3.

[28] State News Service. Airmen work to restore Radio Communications in Puerto Rico. Oct. 23, 2017.

[29] Interview #12 with Telecommunications Regulatory Official. Project 25 (P25) is a process to establish wireless communication standards for the public safety community. Associated Public-Safety Communications Officers, Incorporated (APCO). Project 25 Steering Committee BY-LAWS. (April 16, 2018).

Damage to public safety networks were numerous. PTCs' networks, which interconnect with emergency communications services, even though they were active for a period of time, were unable to activate their services due to power outages and damages to other networks with which they interconnect.[30] Based on interview data, the portfolio of government clients of some PTCs included security and emergency organizations such as firefighters, health services, and hospitals, among others. When discussing the effects of the telecommunications collapse on health services, a participant mentioned the following:

> A lot of communication that couldn't be done and that could possibly have had an impact on the accounting of the missing and the deaths. Ultimately, the effect it had on communications for first responders was disastrous.[31]

Wireless telecommunication services between the 78 municipalities of Puerto Rico, including the islands of Vieques and Culebra, were very scarce, if not null during the following weeks. On this matter, the FCC affirmed that "All *municipios* in Puerto Rico had greater than 75 percent of their cell sites out of service. Forty-eight out of the 78 *municipios* in Puerto Rico had 100 percent of their cell sites out of service."[32] Wireless telecommunications services, the dominant telephone service, "at its worst, 95.6 percent of the cell sites were out of service in Puerto Rico."[33]

Six months after Hurricane Maria, as part of a fact finding visit to Puerto Rico and the Virgins Islands, FCC Chairman Ajit Pai's remarks provide a description of Puerto Rico's

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[30] Some of them also contracted services from private telecommunications companies for data transmission services, support tasks, maintenance and security.

[31] Interview #11 with Telecommunications Regulation Specialist. See Kishore et al (2018) for an assessment on the total number of official reported deaths and the lack of telephone services during the response and recovery phases.

[32] FFC. (2018). Atlantic Hurricane Season Impact on Communications Report and Recommendations. Public Safety Docket No. 17-344. DC: FCC. P.5. The word *municipios* refers to counties.

[33] FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations. Public Safety Docket No. 17-344. P.15.

communications infrastructure damages that still included, "poles down, cell towers toppled, electrical power depleted, and otherwise unavailable, wireless infrastructure completely destroyed, many radio and television broadcast facilities impacted."[34] The TBPR estimated damages to the communications network at $1.5 billion.[35]

5.2 Factors affecting the restoration of telecommunications services

In regard to the third research question, participants identified the following factors as the more influential in the process of restoring emergency communications services during the response and recovery phases: 1) Lack of electricity and dependence on PREPA's electricity service, 2) Difficulties in access and security of fuels for backup powers systems and transportation, 3) Hurricane Irma's degrading effects in the electrical power and telecommunications networks, 4) Human made damages (i.e. questionable practices during debris cleaning and restoration of the electrical system), and 5) Aerial deployment of fiber optics.

On the issue of lack of electricity and dependence on the Puerto Rico Electric Power Authority service, all participants considered it the main factor in the restoration process. In relation to the extended power outages and wireless telephone services availability, a participant stated:

> If the electrical power connection was lost, they used the backup power, which
> are generally small because they serve small areas and their specifications at the
> tolerance level that will be given for a certain time. It is possible that the plants
> could supply energy for eight hours and after that the tanks had to be refilled and
> without the transportation mechanisms or the closed or blocked roads, the cell
> tower lost its service and left all the clients of that area without service. That was

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[34] FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations Public Safety Docket No. 17-344. P. 27.
[35] Torres López, S. E. (2017). Letter to Ajit Pai, Chairman. FCC WC Docket No. 10-90, at 1 (filed Dec. 13, 2017).

what caused more than 95 percent of cell phone customers to lose their services after the hurricane. That experience was very similar for almost all cell phone companies.[36]

Participants also discussed the difficulties in fuel access and security for backup power systems and transportation. Regarding the distribution of fuels, a participant commented:

When the event occurs, federal agencies arrive, specifically FEMA, and take control of all fuel supplies with the intention of them establishing their recovery process…But that in turn meant that local operators did not have access to fuel when they needed it. And that's one of the critical points because everything runs on power and we need the generators running.[37]

A particular feature of the restoration process was the ongoing recovery mode in place after Hurricane Irma's impact just two weeks before Hurricane Maria. According to some participants, that was a main factor in restoring telecommunications services after Hurricane Maria.[38] On this matter, a participant commented: "I think, back-to-back events posed a unique challenge because you were already in emergency mode and you had to beat another emergency mode."[39]

Participants also mentioned human-made damages related to the difficulties in coordination during debris cleaning and restoration of the electrical system, particularly between the Puerto Rico Electric Power Authority, the TBPR, and telecommunications companies. For example, transmission paths, and fiber optic and coaxial cables were cut along with branches and trees that were removed in order to provide vehicular access and antenna misalignment. In relation to this practice, a telecommunications regulatory specialist stated:

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[36] Interview #11 with Telecommunications Regulation Specialist.
[37] Interview #6 with Senior Executive.
[38] This opinion was also subscribed by the FCC. FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations Public Safety Docket No. 17-344. P.5.
[39] Interview #4 with Senior Executive.

The Electric Power Authority in its process of reestablishing service, cut fiber optic cables for telephone distribution. We did not lose the service as a consequence of the hurricane, but we did lose it in the recovery process because contractors or employees of the Authority *motu propio* decided to cut them in order to advance the restoration of the electrical power service.[40]

Another factor identified by some of the participants was the aerial deployment of fiber optics. Historically, fiber optics were deployed mainly overhead, with underground fiber optics lagging behind, mostly due to high installation costs for underground fiber optics. On this matter, a participant stated:

When we left the metropolitan area, and this is what happens to most carriers, almost all infrastructure is overhead. In the wake of the storm, initiatives have been made to underground sections to help mitigate the impact on future events. But most of the infrastructure outside the metropolitan area is aerial.[41]

5.3 Policy examination of FCC, TBPR and PTCs' interaction and outcomes

This section addresses the FCC and the telecommunications industry interaction during the response and recovery phases are outlined under two rubrics: Emergency Management Activities and Adoption of Policy Tools.

5.3.1 Emergency management activities

The FCC activated its Incident Management Team (IMT), a technical and policy experts group from other FCC's Bureaus and Offices. The IMT's activities included addressing information and action requests from federal and state government agencies such as the Emergency Operations

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[40] Interview #12 with Telecommunications Regulatory Official.
[41] Interview #6 with Senior Executive. In relation to fiber optics costs another participant stated: "I mean we looked into this. I mean the cost was prohibitive. It was like 10 times the cost of aerial which is why people don't do it…So that may be another example of where you need government assistance". Interview #10 with Senior Executive.

Center of the GPR, the TBPR and PTCs. During the response and recovery phases the FCC activated the Disaster Information Reporting System (DIRS) and over the next two months issued daily Communications Status Reports about Puerto Rico and US Virgin Islands.[42]

In relation to Puerto Rico, the FCC deployed three employees to its Joint Field Office in San Juan. Also, on October 6, 2017, the FCC created a Hurricane Recovery Task Force to transition from short-term to longer-term recovery phase. Both groups provided support in areas such as waivers of FCC rules, the extension of period for the regulatory filings, granting of Special Temporary Authority (STA), personnel support to Roll Call, support in shipping of equipment and materials and other regulatory filings and requests to federal agencies (e.g. United States Environmental Protection Agency).

For the 2017 Atlantic hurricane season and related to Hurricane Maria, the FCC's Bureaus and Offices granted 824 STAs (Wireless Telecommunications Bureau - 717, Public Safety & Homeland Security Bureau - 8, Media Bureau - 85, International Bureau - 5, Office of Engineering & Technology - 9).[43] The FCC data are useful to account the complexities and scale of FCC's activities during Hurricane Maria. However, a specific breakdown of STAs for Puerto Rico was not found. In regard to the specific amount of STAs for Puerto Rico, one participant stated that because of having the Emergency Operations Center, the FCC granted over 300 STA's to just one company during the recovery phase.[44] Participants stated that FCC staff approved "the needed Special Temporary Authority to operate in Puerto Rico as part of our efforts to support a roaming partner on the island".[45]

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[42] The Communications Status Reports were generally organized under the following categories: 911 Services, Wireless Services, and Cable Systems and Wireline and Broadcasting (combined).

[43] FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations Public Safety Docket No. 17-344. P.21.

[44] Interview #7 with Senior Executives (3 participants).

[45] Interview #10 with Senior Executive.

The FCC STAs facilitated access to frequencies and use of technologies, such as microwaves, granted a request from the American Radio Relay League (ARRL) for amateur data transmissions to facilitate hurricane relief communications between the continental United States and Puerto Rico, waived location accuracy obligations for 911 calls for certain service providers, and waived rules that allowed public safety use of interoperable channels in Puerto Rico. Other examples of the FCC and the industry interaction in the restoration of telecommunications services was FCC granting the deployment of the 600 band and the temporary use of some of our frequencies in the radio spectrum to support Google Looms technology. Also, after the event and for two years approximately, on one week per month basis, the FCC had an expert in public safety spectrum issues available in Puerto Rico.

For over a year the FCC's Public Safety and Homeland Security Bureau issued additional public reports on the status of communications services, public notices seeking comment on communications infrastructure resiliency, and hosted a workshop of government and consumer stakeholders to identify critical information needs and facilitate access to information in support of preparedness and response activities. Also, Ajit Pai, FCC Chairman made two fact finding visits (November 2017 and March 2018) to Puerto Rico during the response and recovery phases. These visits included meeting with stakeholders (state government & public safety officials, industry representatives, and community members in Utuado, Puerto Rico).[46]

5.3.2 Adoption of policy tools

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[46] FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations Public Safety Docket No. 17-344. P. 27.
Also on March 2018 FCC Commissioner Jessica Rosenworcel visited Puerto Rico to assess damages to the communications sector and recovery efforts. More recently, in February 2020 FCC Commissioner Geofrey Starks visited Puerto Rico. See Minelli Pérez, S. (March 8, 2018). La FCC fizcalizará el uso de los fondos para las telecomunicaciones (The FCC will monitor the use of funds for telecommunications). El Nuevo Día.

As part of the administrative provisions, the FCC activated the DIRS system and provided public information regarding state of communications services in Puerto Rico.[47] By December 2017, along the funding allocations to telecommunications carriers in Puerto Rico, the FCC announced a public consultation process seeking comments from stakeholders on the resiliency of the communications infrastructure during hurricanes Harvey, Irma, María, and Nate. The purpose was to obtain "information to better understand how well such access was provided during these hurricanes in order to assess what lessons may be learned for the future." [48] *El Nuevo Día*, the newspaper of record in Puerto Rico, published the FCC public notice and reported that based on their journalistic investigation approximately, 80% of mobile antennas were operating 90 days after the event. This means between six and seven out of 10 antennas were still working with backup power generators due to the extended power outage across the island.[49]

One of the FCC's first economic measures during the restoration of telecommunications services was a first allocation of funds for telecommunications companies in Puerto Rico. (i.e. Suplemental Emergency Support) Telecommunications companies had already expressed the need for financial assistance to restore telecommunications services. In regard to supplemental federal emergency assistance to PTCs, on October 4, 2017, the FCC authorized a first allocation of $77 million for Puerto Rico and the Virgin Islands from the Universal Service Fund High Cost Program to PTCs. Later on, August 7, 2018, the FCC issued a Public Notice announcing the allocation of $64 million for Stage 1 for telecommunications service providers in Puerto Rico and the Virgin Islands. By May 2018, in response to the damages of telecommunications infrastructure in Puerto

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[47] Torres López, S. E. (2018, May 25). Letter to Hon. Henry Neumann Zayas, President, Public Safety Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 708).
[48] FCC. (December 7, 2017). Public Safety and Homeland Security Bureau seeks comment on response efforts undertaken during 2017 Hurricane Season. Public Notice.
[49] González, J. (2017, December 19). La FCC abre proceso sobre efectividad de telecomunicaciones tras María. (The FCC opens a process on telecommunications effectiveness after Maria). El Nuevo Día.

Rico and the US Virgin Islands, the FCC had created the *Uniendo a Puerto Rico* Fund (Bringing

Puerto Rico Together Fund) and the Connect USVI Fund.[50]

More recently, in 2019 the FCC approved $750 million in funding over ten years to

strengthen communications networks in Puerto Rico, 500 million for fixed broadband and $250

million over three years for mobile broadband.[51] Since telecommunications companies are

responsible for restoring service, maintaining and infrastructure hardening, the FCC's financial

assistance goes to companies and indirectly such economic assistance benefits the customer

service. In this sense, according to one of the participants, "So in the way that there is more money

for companies to have infrastructure, I think that this is beneficial for all of us."[52] The policy

objectives of this federal funding allocation are to improve, expand, and harden communications

networks.

5.4 TBPR and the telecommunications industry interaction

This section addresses the TBPR's Emergency Management Activities and Adoption of Policy

Tools.

5.4.1 Emergency management activities

Prior to hurricanes Irma and Maria, on August 22, 2017, the major telecommunications providers

in Puerto Rico signed a cooperation agreement with the TBPR.[53] The purpose of the cooperation

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[50] FCC. (2019, May 8). The Uniendo a Puerto Rico Fund and the Connect USVI Fund. FCC. WC Docket No. 18-143 FCC WC Docket No. 10-90, WC Docket No. 14-58; FCC. (2020, February 5). Uniendo a Puerto Rico Fund and Connect USVI Fund Notice and Filing Requirements and Other Procedures for Stage 2 Fixed Competitive Proposal Process. WC Docket Nos. 18-143, 10-90, 14-58; FCC WC Docket Nos. 18-143, 10-90, 14-58; González, J. (2017, December 19). La FCC abre proceso sobre efectividad de telecomunicaciones tras María (The FCC opens a process on telecommunications effectiveness after María). El Nuevo Día.
[51] FCC. (September 26, 2019). FCC Invests $950 Million to Improve Broadband in Puerto Rico, USVI (Press Release).
[52] Interview #12 with Telecommunications Regulatory Official. The TBPR supported the allocation of financial aid to companies through the Universal Service Fund.
[53] The signatory companies were AT&T, Puerto Rico Telephone Co./Claro, Open Mobile, Sprint, Telefonica Larga Distancia, T-Mobile Puerto Rico, WorldNet Telecommunications, Liberty Cablevision & PREPA Networks. Torres López, S. E. (February 4, 2019). Letter to Hon. Víctor L. Pares Otero. President, Economic Development, Planning,

agreement was to "to unite efforts between public and private entities in order to restore and protect the telecommunications and cable television infrastructure, and meet priorities arising from disasters or emergencies."[54]

After Hurricane Maria and for the following 60 days approximately, the TBPR organized daily meetings with representatives of telecommunications companies and established its own Telecommunications Operations Center (COT) in the facilities of the Government Command Center, with the purpose of dealing with incidents from the telecommunications industry and government agencies. There, in collaboration with DHS, FEMA, the FCC and other federal entities, TBPR staff and the Puerto Rico Innovation and Technology Service (PRITS), the telecommunications companies carried out support activities for the restoration of telecommunications services (e.g. PTCs Daily Status Reports).[55] Other activities of the TBPR, in conjunction with CTIME, included the management of a telephone bank for first responders and people in transit at the airport and ports.[56]

In addition to providing satellite telephones (22) to the Governor's Office and heads of designated agencies for use during emergency situations, during this period the activities of the TBPR included the use of an interactive map of the critical telecommunications infrastructure in Puerto Rico, identification and security for the distribution of fuels, supported various orders for

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Telecommunications, Public & Private Alliances and Energy Commission, Representatives of Representatives of Puerto Rico (Explanatory Report for House of Representatives Resolution 64).

[54] The agreement was renewed in June 2019. See Serrano-Román, (2019, June 19). Acuerdo permitirá mejorar el restablecimiento de las telecomunicaciones después de una emergencia (Agreement will improve the restoration of telecommunications after an emergency). El Nuevo Día.

[55] The Telecommunications Operations Center was opened on September 20, 2017. See PRTRB Administrative Order JRT 2017-004, October 10, 2017; PRTRB. Order JRT-2017-OA-0003, September 18, 2017; Torres López, S. E. (2018, May 25). Letter to Hon. Henry Neumann Zayas, President, Public Safety Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 708).

[56] For instance, AT&T supplied 103 telephones for First Responders. Also, the TBPR and CTIEM's agreement provided for an inventory of "at least thirty (30) cell phones activated by company (subject to availability) to be used by representatives of the state and federal government, according to priorities during an emergency, and after these have exhausted their resources." See Torres López, S. E. (2018, May 25). Letter to Hon. Henry Neumann Zayas, President, Public Safety Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 708).

exemptions of state and municipal permits for telecommunications companies to make arrangements and construction of their infrastructure, relief of taxes for equipment and materials destined for the recovery phase, and access to the backyards and easements without civil or criminal liability.[57]

Several participants described favorably TBPR's emergency management activities during the period of response and recovery phases.[58] In response to the need of information to restore emergency communications and wireless telecommunications services, a project developed by the TBPR, was the adoption of Map Plus, an electronic system that traced telecommunications services connectivity and outages according to geographical coverage areas. This initiative was reiterated by several participants as an important instrument that supported the restoration of emergency communications.[59]

5.4.2 Adoption of policy tools

In regard to TBPR's resolutions and orders during the first three weeks after Hurricane Maria, on October 10, 2017, the state regulator requested from PTCs to provide detailed information on the recovery of essential infrastructure of telecommunications. According to the TBPR, aside from the voluntary information from the PTCs provided during the response phase, the state regulator "still continue to face problems with getting data from companies, despite the fact that they have a duty to report to the Federal Communications Commission (FCC), once the

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[57] See Torres López, S. E. (2018, May 25). Letter to Hon. Henry Neumann Zayas, President, Public Safety Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 708); Interview #12 with Telecommunications Regulatory Official.

[58] Interview #5 with Senior Executive.

[59] The context for this resource is traced back to Hurricane Irma. After Hurricane Irma the TBPR asked the FCC's Public Safety and Homeland Security Bureau information about critical telecommunications infrastructure in Puerto Rico. Because the information reported by the companies to the DIRS system was confidential, the information request didn't materialize. Its noteworthy that in the Order from October 10, 2017, that affirmed the problems to get information from PTC's, the state regulator also stated that it can't receive information related to critical telecommunications infrastructure from the FCC.

Disaster Information Reporting System (DIRS) has been activated. This information is not shared with the states."[60] The order's mandate, a prescriptive policy tool, required daily information reports from PTCs, that included fines for incompliance, a Restoration Plan from each company.[61]

In relation to consumers, the TBPR issued a statement and order requiring PTCs to provide information related to the granting of the credits to consumers. Specifically, a description of the type credit and the time frame without service, the number of billing cycles with credits to consumers, how the credits were communicated to their clients and how many clients have requested credit for service outages. It is worth mentioning that before the order telephone service providers offered credits to consumers, which fluctuated between 60 or 90 days of service. PTCs also voluntarily agreed to give credits to other telecommunications companies due to the inability to interconnect between them.[62]

After the response and recovery phases, other policy tools to further emergency communications objectives were TBPR's agreements with the Patriot Amateur Radio Emergency Club and the Federation of Radio Amateurs of Puerto Rico (*Federación de Radioaficionados de Puerto Rico*).[63] Also, in regard to public safety organizations, the TBPR collaborated with other emergency communications partners in the Central Recovery and Reconstruction Office's *Report*

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[60] PRTRB. Administrative Order JRT 2017-004, October 10, 2017. Translation by the authors.

[61] On the matter of compliance with the voluntary reporting to the DIRS system, later in 2018 the FCC provided information on PTCs participation in DIRS during the aftermath of Hurricane Maria. It affirmed: "During Hurricane Maria, the major incumbent local exchange carrier and cable providers in Puerto Rico and the USVI did not provide detailed information in DIRS. In some cases, the lack of participation was due to service providers' loss of communications which precluded access to the DIRS platform. In other cases, service providers may not have been aware of DIRS prior to the hurricanes." FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations Public Safety Docket No. 17-344. P.28.

[62] See PRTRB. Resolution and Order JRT-2017-CCG-0002, November 11, 2017; Torres López, S. E. (November 7, 2017). Letter to Hon. Miguel A. Laureano Correa. President, Innovation, Telecommunications, Urban and Infrastructure Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 457).

[63] Torres López, S. E. (2018, May 25). Letter to Hon. Víctor L. Pares Otero. President, Economic Development, Planning, Telecommunications, Public & Private Alliances and Energy Commission, Representatives of Representatives of Puerto Rico (Explanatory Report for House of Representatives Resolution 64).

on Puerto Rico Critical Communications Preparedness for the 2018 Hurricane Season [64], and in

2019 Puerto Rico Emergency Management and Disaster Bureau's *Joint Operational Catastrophic*

Incident Plan of Puerto Rico, the renewal of cooperation agreements between the TBPR and the

Puerto Rican Alliance for Telecommunications, and policy briefs to several state hearings on the

telecommunications industry emergency plans.[65]

5.5 Wireless industry self-regulatory practices during emergency situations: The roaming

service agreement

Before and during the first days of Hurricane Maria's landfall, several PTCs reached confidential

cooperation agreements for the transportation of generators, materials and personnel, access to

submarine cables, and preliminary agreements for roaming services between companies. Also,

during the process of reestablishing telecommunications networks, other companies adopted

written and verbal agreements of cooperation for interconnection services, exchange of materials

and equipment, and acquisition and repair of equipment.[66]

Other initiatives adopted by the telecommunications providers to mitigate the loss of

telecommunications services were the deployment of Satellite Cells on Light Trucks (COLTs) and

Cell on Wheels (COWs). Of these PTCs' cooperation initiatives, in relation to emergency

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[64] The agencies that collaborated in the report were the TBPR, Puerto Rico Department of Public Safety, DHS, FEMA, FCC National Coordinating Center for Communications, Mobile Emergency Response Support Team, and the National Telecommunications and Information Systems. See (2018, May 25). Torres López, S. E. (2018, May, 25). Letter to Hon. Henry Neumann Zayas, President, Public Safety Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 708).

[65] The *Joint Operational Catastrophic Incident Plan of Puerto Rico* was approved in August 18, 2019. However, in 2018, a year after Hurricane Maria, the Puerto Rican Alliance for Telecommunications, a professional organization representing telecommunications companies in Puerto Rico, expressed its disappointment because the GPR had not summitted its new emergency communications plan to the telecommunications industry. On the contrary, by then PTCs had complied with the legal and regulatory mandates to provide new emergency communications plans to the regulator while undertaking voluntary network hardening and emergency communications related investments. See Suárez, D. (2018, September 12). Desconectadas empresas de comunicaciones de nuevo plan emergencia. *Noticel*; Minelli Pérez, S. (2018, December 30). La reparación en telecomunicaciones dio paso a sentar las bases para 5G. *El Nuevo Día.*

[66] Interview with Senior Executives #7.

communications access to citizenry and first responders, several respondents considered the cooperation agreement between the wireless carriers as the main one. This agreement is based on the 2016 Wireless Resiliency Cooperative Framework, supported by the FCC on December 14, 2016.[67] The framework is a voluntary mechanism enacted by wireless carriers during emergency situations that provides continuity of wireless services (roaming) to subscribers of wireless services (citizens), first responders and public safety systems. As noted by GAO, the agreement was in response to "FCC's 2013 notice of proposed rulemaking on wireless network resiliency."[68]

In 2016 the signatory companies of the framework included: AT&T Mobility, Cellular Telecommunications Industry Association (CTIA), General Communication Inc. (GCI), Southern Linc, Sprint, T-Mobile, U.S. Cellular and Verizon Wireless. The agreement sets five objectives, of which four are directly related to restoring mobile telephony services during emergency situations.[69]

Based on the Wireless Resiliency Cooperative Framework in 2016 and the fact that no single company could restore the mobile phone services, the agreement was adopted to establish a roaming phone service. The Puerto Rican Alliance for Telecommunications supported the agreement and the TBPR endorsed it. For instance, there were companies that could extend the roaming service to other competing companies, allowing the coverage area to be expanded. In this regard, a participant mentioned:

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[67] The Competitive Carriers Association also endorsed the cooperative framework. FCC. (2016). Wireless Resiliency Cooperative Framework. The Competitive Carriers Association also endorsed the cooperative framework.
[68] U.S. Government Accountability Office. (2017). FCC Should Improve Monitoring of Industry Efforts to Strengthen Wireless Network Resiliency. DC: GAO. P. 23.
[69] The objectives related to our analysis are: 1) Provide reasonable roaming under disaster arrangements when technically feasible, 2) Foster mutual aid among wireless providers during emergencies, 3) Support municipal preparedness and restoration with local government public safety representatives and develop best practices and establishing a provider/PSAP contact database, 4) Improve public awareness and stakeholder communications on service and restoration status, through Commission posting of data on cell site outages on an aggregated, county-by-county basis in the relevant area through its Disaster Information Reporting System.

There were pieces of Sprint and Open that could roam on Claro. But Claro, AT&T, and T-Mobile could roam based on their LTE and based on their GSM infrastructure under lane. And then we quickly found out that some of the handsets that Sprint had actually sold came from Europe which meant they had a GSM chip set. So, we quickly then started turning on those numbers as well to allow those guys to roam on our network…It actually cost a lot of problems because there was no continuous coverage all the way to any one place…So it wasn't the most perfect of networks but that, at least, allowed somebody to call somebody to say "I need help".[70]

A favorable outcome of the framework was that alongside the wireless carriers' efforts to provide a roaming service, other telecommunications companies endorsed and provided support to this initiative. Another group that benefited from this cooperative agreement was the first responders, as they obtained another communication system to carry out safety, health, and other support activities.

Approximately, three weeks after Hurricane María, on October 10, 2017, the FCC reported that the four major wireless companies had opened up a roaming service that could benefit 54% of the population subscribed to wireless services.[71] The roaming agreement concluded once wireless carriers reached between 50 to 60 percent of their service in order to avoid affecting the service of other companies.[72] Later, on November 5, 2017, almost seven weeks after Hurricane Maria, the TBPR reported that service had reached 50%.[73]

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[70] Interview #7 with Senior Executives (3 participants).

[71] FCC. (October 10, 2017). Communications Status Report for Areas Impacted by Hurricane Maria October 10, 2017. Primera Hora, a local newspaper provided an earlier date, circa October 2, 2017, approximately two weeks after Hurricane Maria. The source indicates the agreement to provide a roaming service benefits nearly 2.5 million mobile subscribers. By then, only 12% to 15% of the telecommunications infrastructure had been repaired. See Rivera Cruz, Y. (2017, October 2). Acuerdo entre Claro, T-Mobile y AT&T beneficia a 2.5 millones de usuarios (Agreement between Claro, T-Mobile and AT&T benefits 2.5 million users). Primera Hora.

[72] Interview #12 with Telecommunications Regulatory Official.

[73] The report doesn't specify if the 50% refers to a specific service (e.g. wireline, wireless) or is an aggregated number. Torres López, S. E. (May 25, 2018) Letter to Hon. Henry Neumann Zayas, President, Public Safety Commission, Senate of Puerto Rico (Explanatory Report for Senate Resolution 708). P.6.

The roaming service agreement adopted in 2017 by the principal wireless carriers (AT&T, Claro, Open Mobile, Sprint and T-Mobile) was a positive factor in the restoration of emergency communications and telecommunications services during the response and recovery phases.[74] The roaming agreement was considered by various participants a historic initiative and it had a direct impact on citizens and first responders' ability to perform their work. Nonetheless, data show that initially half of the total wireless subscribers benefited from the roaming service, and due to the prolonged restoration of wireless services and other telecommunications services access to emergency communications services — a policy objective — the service was significantly limited to citizens. Hence, emergency communications (i.e. 911 emergency service, wireless services) outages compromised the citizenry's use of safety and health services, and social media platforms (e.g. Tweeter, Facebook, Instagram, WhatsApp) for communication activities during the emergency.

5.5.1 GAO and FCC Assessments on the Wireless Resiliency Framework

On December 2017 GAO published the report entitled *FCC Should Improve Monitoring of Industry Efforts to Strengthen Wireless Network Resiliency*. The time frame of the report was from 2009 to 2016 and its focus were trends in mobile wireless outages attributed to physical incidents, federal agencies and industry steps to improve wireless network resiliency, and a classification of stakeholders' proposed measures that can be adopted by federal agencies. In relation to the Wireless Resiliency Cooperative Framework, as it relates to our analysis on emergency communications in Puerto Rico, the main consideration from GAO's report is the concern from various stakeholders on whether the framework represented a sufficient path forward due to the

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[74] Other telecommunications companies endorsed the roaming service agreement, such as Verizon and Neptuno Networks.

following factors: 1) Lack of federal agency enforcement or monitoring, 2) Adequate testing to enable roaming under disasters, 3) High threshold to trigger the response elements in detriment of local events.[75] In lieu of the previous issues and to improve wireless network resiliency GAO submitted recommendations in three areas of action: preparedness, response, and awareness. Three executive actions were submitted to the FCC: 1) Develop specific and measurable objectives, 2) Plan to monitor the outputs and outcomes that serve to document and evaluate results, 3) Promote awareness of state and local public safety officials and industry stakeholders through outreach mechanisms.[76]

Later, in 2018 the FCC published the *2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations* that completed the documentation and assessment of the 2017 hurricane season. In regard to the Wireless Resiliency Cooperative Framework, the FCC accounts for various stakeholders' favorable opinion of the Framework's outcomes. The report also poses T-Mobile wider view of the Framework as it recommended to the FCC to consider "a similar approach to cover the entire communications ecosystem, including backhaul providers to provide faster and more complete service restoration."[77] In relation to the Framework, the report made a series of voluntary recommendations that we have classified under two categories: Emergency Management Initiatives and Communication and Outreach Activities. The emergency management initiatives aim to: 1) Widen the number of signatory companies and encourage backhaul providers to work cooperatively with wireless service providers, and 2) Reach other voluntary industry commitments from Framework signatory companies to provide detailed

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[75] U.S. Government Accountability Office. (2017). FCC Should Improve Monitoring of Industry Efforts to Strengthen Wireless Network Resiliency. DC: GAO. P. 3-4, 27.
[76] U.S. Government Accountability Office. (2017). FCC Should Improve Monitoring of Industry Efforts to Strengthen Wireless Network Resiliency. DC: GAO. P. 36.
[77] FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations Public Safety Docket No. 17-344. P. 29.

information when the Framework is active and making it public on an aggregated and anonymous basis, 3) PSHSB active engagement with emergency management partners (e.g. Critical Infrastructure and SLTT governments) during disaster situations to better address and position communications needs.[78]

5.6   Review of the Emergency Communications State Regulatory Reform

During the response and restoration phases, Puerto Rico's State Senate (3) approved three resolutions to carry out investigations about the telecommunications industry response to Hurricane Maria and the industry readiness in 2018.[79] Moreover, Table 4 shows three state laws approved from January 2018 to 2019 that reformed the state emergency communications regulatory regime.

Table 4: Laws approved for the Telecommunications State Regulator, 2018-2019

Law	Purpose
Law No. 5, January 20, 2018	To amend subsection (a) of Article 2 of Chapter I of Act 213-1996, known as the Puerto Rico Telecommunications Act.
Law No. 211, August 12, 2018	Law of Execution of the Reorganization Plan of the Public Service Regulatory Board of Puerto Rico
Law No. 22, May 15, 2019	To add new Article 8A to Chapter III of Act 213-1996, as amended, known as the "Puerto Rico Telecommunications Act 1996", in order to require providers of telecommunications services a contingency and continuity plan for services in the face of a duly declared emergency or disaster; and for other related purposes.

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[78] FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations Public Safety Docket No. 17-344. P. 28-29.

[79] Puerto Rico's Senate Resolution Num. 457, October 23, 2017; Puerto Rico Senate Resolution Num. 467, October 24, 2017; Puerto Rico Senate Resolution Num. 708, April 16, 2018; Puerto Rico Senate Resolution Num. 708, April 16, 2018. In response to Puerto Rico's House of Representatives Resolution Num. 64, from January 18, 2017, the TBPR also submitted a detailed report on the state of the telecommunications industry after Hurricaine Maria.

In 2018 Law No. 5-2018 declared public policy to recognize "telecommunications as an essential service", placing it alongside other essential services such as the production and distribution of electrical power and potable water. In relation to Law No. 5-2018, a telecommunications regulatory specialist stated:

> That came because the telecommunications service was not seen as a priority…Now the Bureau can require other government agencies to contribute to maintaining the service because it helps the Government, first responders and recovery efforts. It allows the Bureau to ask for certain things within its design plan to make the system more resilient. As the ministerial function of the Bureau is to ensure compliance with public policy at the telecommunications level, it can request it and at the same time federal agencies are involved in the process.[80]

The second measure was Law No. 211, of August 12, 2018, known as the Execution Law of the Reorganization Plan of the Puerto Rico Public Service Regulatory Board (PRPSB), created a new regulatory agency. According to the explanatory statement, the "Law does not intend to change the public policy of the Government of Puerto Rico on this subject. Its main intention is to adjust the new organizational and administrative structure to the current legal order".[81]

Law No. 22, of May 15, 2019 directed its attention to emergency communications. The legislators' objective was to strengthen state regulation in the field of emergency communications through different policy tools aimed at two subjects: the TBPR and PTC's. Law No. 22 - 2019 mandates to the state regulator new policy objectives such as:

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[80] Interview with Telecommunications Regulatory Official #12. See Torres López, S. E. (December 7, 2017). Letter to Hon. Miguel A. Laureano Correa. President, Innovation, Telecommunications, Urban and Infrastructure Commission, Senate of Puerto Rico (Explanatory Report for Senate Project 711). The TBPR endorsed the senate project that resulted in the approval of Law No. 5 - 2018.

[81] As an umbrella organization, the PRPSB brings together the Telecommunications Bureau of Puerto Rico, the Energy Bureau of Puerto Rico and the Transportation and Other Public Services Bureau of Puerto Rico.

1) Establish TBPR's functions during an emergency situation aimed at to restoring communications infrastructure and networks.

2) Lead efforts to coordinate, establish, and maintain federal, state, and local communications during emergency situations.

3) Create and manage a radio amateurs bank to support to support public safety activities during emergency situations.

4) Support the 911 Emergency System Bureau under to the Department of Public Safety.

5) TBPR authority to carry out inspections, investigations and audits, if necessary, to achieve the purposes of this Law.

Law No. 22 - 2019 while reaffirming the jurisdiction of the state regulator conditioned PTC's licensing to the state regulator examination and approval of their contingency and continuity plans for a duly declared emergency or disaster. Article III-8A of the new law provided that "through this plan, the Company will establish the necessary mechanisms to, to the extent possible, to maintain the continuity of the services and operations that they offer to the public".

Law No. 22 - 2019 set in the state regulator the responsibility for the approval of the contingency plans and ordered that they be in accordance with the State Emergency Management Plan of the Government of Puerto Rico. However, Law No. 22 - 2019 sets an administrative procedure consistent with Law No. 5 - 2018 establishing a shared responsibility, between the Department of Public Safety and the TBPR. In this sense, and in order to comply with Law 5-2018, the Department of Public Safety was ordered to coordinate the integration of the TBPR and certified telecommunications providers in the development, management and implementation of the State Plan for Emergency Management. Furthermore, Law No. 22 - 2019 established *in situ* inspection of infrastructure sites by the state regulator as part of the certifications process and the

ability to take administrative measures, "including notifications of non-compliance and, if necessary, the imposition of fines up to a maximum of five thousand (5,000.00) dollars, to ensure faithful compliance with what is established herein."[82] Prior to 2019, mandatory state regulatory field inspections related to emergency communications were not required. In sum, Law No. 22 - 2019 reflects the state government intervention in the telecommunications industry, as opposed to a regulatory tool, that sets a new legal mandate through the PTCs licensing granting process.

The laws discussed above were approved for the telecommunications state regulator and aimed at strengthening the powers, setting new policy objectives, policy tools and intergovernmental procedures for the TBPR. These laws amended the Puerto Rico Telecommunications Act of 1996. (Law No. 213 -1996) and during the legislative process received TBPR's support. In particular, Law No. 22 - 2019 showed that at a state level the policy making process had resulted in a political and legal reform aimed at strengthening emergency communications policies. Based on these developments, we can conclude that the state legislator and regulator showed a vigorous stand by intervening, as opposed to regulating, in the emergency communications field and the roles for the regulator and PTCs.

6. Conclusions

This study examined emergency communications policies in Puerto Rico during the response and recovery phases after Hurricane Maria in 2017 using a qualitative analysis of PTCs' responses and a policy analysis of the emergency communications regulatory framework, the conduct of federal and state regulatory institutions and PTCs' adoption of the Wireless Resiliency Cooperative Framework, and the regulatory and intervention measures by the state legislative body between 2017 and 2019.

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[82] Puerto Rico. Law No. 22, of May 15, 2019. P.2. Translation by the authors.

Due to the limited number of participants in the survey, the research questions presented in the paper can only partially be answered and cannot be generalized to all other PCTs. A general conclusion drawn for the results is that the majority of participants didn't consider favorably and didn't have an opinion on strengthening emergency communications polices at the federal level (RQ1). Similarly, the results show that the majority of opinions considered emergency communications policies at the state level not adequate, and only half of participants favored strengthening state regulation (RQ2). In relation to this conclusion a participant stated:

> I think expecting and ordering and demanding that the industry get together for the better of the island…It's a great idea and it's a great thought … this is where regulation has to step in. When market forces work contrary to society's, that's when you have to have better regulation. And this is one of those situations.[83]

In regard to the role of external and structural factors (RQ3), the results suggest that such factors (e.g. lack of fuel and backup power systems, inadequate debris cleaning practices, and reliance of aerial fiber optics deployment) were highly consequential and affected both the execution of existing emergency communications policies as well as the development of alternative policies.

At a more nuanced level of analysis, the policy analysis of emergency communications policies in Puerto Rico examined the interaction of the FCC, the TBPR and PTCs based on the emergency management activities carried out and the policy tools adopted. Their activities were contextualized according to emergency communications policy objectives, the historical trends mentioned above, and the specific factors related to Hurricane Maria's catastrophic impact noted by the research's participants, regulatory institutions, and governmental and academic literature.

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[83] Interview #10 with Senior Executive.

This study was grounded in two principles of telecommunications policymaking proposed by Picard and Pickard (2017). The first one suggests that policies should allow the public to communicate with authorities and among themselves. The 911 emergency service was an active designated emergency service number before the event but for several months after the event, access and adoption of the 911 emergency service was highly limited to citizens and first responders due to the technical damages and an extended power outage. Aside from the adoption of the Wireless Resiliency Cooperative Framework, the results demonstrate that in Puerto Rico, in the immediate aftermath of Hurricane Maria, both federal and state emergency communications policies already in place were initially ineffective, largely due to the external factors discussed above and to limited short-term power outages policy requirements.[84]

In comparison, state regulators were more aggressive than federal regulators in intervening in the telecommunications industry. State legislation was more vigorous than the federal efforts by mostly intervening in the telecommunications sector, as opposed to primarily regulating it. Additionally, restoring the power grid had an impact in the restoration of telecommunications systems revealing the lack of coordination of public safety organizations and PTCs during the emergency. Between 2017 and 2019, several policy instruments and agreements between PTCs and government agencies were put in place to address the structural and implementation failures. Hence, policymaking and policy tools application in regard to emergency communications were largely reactive.

The second principle suggests that policies should allow authorities to communicate directly to the public and to enhance communication among authorities themselves. The results

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[84] See FCC Commisioner Geoffrey Starks' comments on PTCs outcomes during Hurricaine Maria recovery phase. Pacheco Santa, G. (2020, February 22). La FCC admite que su respuesta tras el paso de María debió ser más eficiente (The FCC admits that its response after María's passage should have been more efficient). El Nuevo Día.

show that communication from authorities to the public was hampered by the same factors described above under the first principle. In regard to communication between authorities, the results show that at the time of the event access to early warning systems such as EAS, WEA/CMAS, IPAWS were available.[85] After the event these services were limited due to technical damages and an extended power outage. The information examined suggests that access and adoption of enhanced technology to support first responder's activities was limited. Data from the in-depth interviews indicated funding difficulties to meet federal technological standards. After the event broadcasting services (e.g. terrestrial and satellite), wireless services (e.g. Wireless Resiliency Cooperative Framework), FCC's DIRS system, and TBPR's Map Plus System provided a multiple technologies approach to avoid single technology disruption during emergency situations. However, voluntary reporting to the FCC's DIRS system didn't include the information from some PTCs.[86] Further research is necessary to address public safety organizations communications networks.

Drawing from Cherry (2006), after Hurricane Maria the reform of emergency communications regime shows two distinctive policy making processes at the federal and state realms. The FCC have addressed the economic viability for carriers' networks reconstruction and hardening, through supplemental and long-term funding allocations. Meanwhile the political feasibility of emergency communications polices was the state legislator's task, as its intervention resulted in new rules and workflows for PTCs and the TBPR.

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[85] Interview with Telecommunications Regulatory Official #12, Interview with Telecommunications Regulatory Official #15.

[86] In 2018 the FCC affirmed: "During Hurricane Maria, the major incumbent local exchange carrier and cable providers in Puerto Rico and the USVI did not provide detailed information in DIRS. In some cases, the lack of participation was due to service providers' loss of communications which precluded access to the DIRS platform. In other cases, service providers may not have been aware of DIRS prior to the hurricanes. FCC. (2018). 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations Public Safety Docket No. 17-344. P.28.

This study also aimed at improving emergency communications policy making processes and their outcomes by providing practical recommendations based on the findings reported in the results section. One of the study's findings is that after Hurricane Maria, telecommunications companies made investments in technology and have reevaluated their emergency plans.[87] Based on the participants' responses, nine applicable recommendations were identified:

1. Establish government approved procedures for the distribution of fuels to telecommunications companies during emergency situations.

2. Strengthen public safety communication systems.

3. Create a tax incentive program for the broadband market in order to encourage competition and acquisition of resilient technologies

4. Establish a subsidy program to improve infrastructure such as underground fiber optics, and acquisition of resilient technologies.

5. Strengthen the exchange of information between federal and state agencies during emergency communications.

6. Evaluate underwater infrastructure vulnerabilities due to its geographical position and increase and decentralize the number of cable mooring points.

7. Revisit the proposal to use the underground infrastructure of the Department of Transportation and Public Works in the metropolitan area (San Juan).

8. Designate Hot Zones across the island so that telecommunications service providers are required to offer free access to "Wi-Fi".

9. Re-evaluate the use of satellite technology in regard to satellite bandwidth to support emergency communications.

These recommendations include a mix of policy tools that are aimed at strengthening federal or state emergency communications policies, and some of them are already at a development stage.

The implications and recommendations of this study, although particular to Puerto Rico, may further research in emergency communications in contexts of extreme infrastructure collapse. Furthermore, other media and telecommunications policy research topics are derived when emergency communications policies are considered as a legal framework that asserts the citizens' right to communicate with its community and public safety organizations during emergency situations.

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APPENDIX 1

Interviewee List

Telecommunications Company	**Position**	**Code**
Telecommunications Company #1	Senior Executive	1
Telecommunications Company #2	Senior Executive	2
Telecommunications Company #3	Senior Executive	3
Telecommunications Company #4	Senior Executive	4
Telecommunications Company #5	Senior Executive	5
Telecommunications Company #6	Senior Executive	6
Telecommunications Company #7	Senior Executives (3 participants)	7
Telecommunications Company #8	Senior Executive	8
Telecommunications Company #9	Senior Executives (2 participants)	9
Telecommunications Company #10	Senior Executive	10
Telecommunications Expert		11
Telecommunications Regulatory Official		12
Telecommunications Regulatory Official		13
Telecommunications Expert		14
Telecommunications Regulatory Official		15