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Developing a Robust Emergency Information System for Natural Disasters

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Abstract: A lot of Emergency Information Systems have been developed to inform people about impending emergencies. Most of them are part of an integrated system, collaborating with a respective warning system. No matter which technology is employed in the development process, an Emergency Information System aspires to deliver emergency content accurately and rapidly. Most of Emergency Information Systems transmit the emergency content in a predetermined geographical area. In parallel, a typical DRM Emergency Information System doesn't vouch for transmission accuracy in the case of a possible communication loss or a power outage. This paper presents a DRM-based Emergency Information System that works well in remote areas with rough geographical terrain, offsetting a possible communication loss or a possible power outage. An efficient broadcast selection algorithm has been developed to answer this purpose. The paper also indicates the maximum coverage of the underlying system, in a mountainous area (Vigla), taking advantage of a standard methodology called " LEGBAC". Specific software was used to come up with the wide area coverage map. The results proved that our system achieved maximum coverage in any antenna calibration (99% approximately) and the value of the respective signal strength was not significantly altered by the increase in the number of kilometers away from the transmission center, indicating the robustness of our system and the competency of the broadcast selection algorithm.

Keywords: Warning System, Coverage Prediction, Emergency Information System

1. Introduction

In recent years, a boom in natural disasters has necessitated the development of Emergency Information Systems. A critical issue that arises is the loss of communication systems in the event of a power outage. It is important to point out that a typical DRM system is not equipped to offset a possible communication loss or power outage.

Another issue pertains to the quality of the emergency information provided [1]. Some studies focus on another issue, denoting that Emergency content should be delivered rapidly and accurately [1-4].

A further important issue stresses the fact that technologies such as the internet and wireless networks are not always available in remote areas. This holds, especially in the case of remote islands. Therefore, other technologies should be employed to cover the need for information.

All the above issues could be addressed by a competent emergency information system. This paper demonstrates such a system that is developed to work in remote areas, offsetting the possible communication loss or power outage through a competent broadcast algorithm. The paper presents the actual as long as the experimental system In parallel, the paper indicates the maximum coverage of the experimental system and the respective signal strength value across the coverage range.

2. Related Work

The literature abounds with studies related to Emergency Information Systems [5-22]. One study refers to an emergency information system for car accidents based on the capabilities of CTV devices. The respective emergency information system achieves high detection rates, but it doesn't work well in all types of car accidents [5]. Another study refers to an emergency information system that secures rail transport safety. VHF 150 MHz radio communication network/GSM-R technology stands out in the architecture of the underlying system [6]. It is important to point out that there is an intrinsic drawback, in terms of the cooperation of the radio communication network and GSMR system. This issue has been addressed by equipping the vehicle with the 150 Mhz/GSM-R dual system radio.

Other studies refer to emergency information systems aiming at informing people about impending disasters such as floods [7, 9, 13, 19, 21, 22]. The emergency information system in these studies is part of an integrated system. Although these systems manage to deliver the information system accurately and efficiently, they do not always manage to be in tune with the respective warning systems.

Additionally, there are a lot of studies referring to the American patent which is related to emergency information systems that take advantage of radio technology [10, 16, 20]. It is essential to point up that one study underlines an important drawback of American patent architecture [16]. The respective system works well in any actual emergency. A drawback is centered on the use of the OFDM technique. Specifically, it is difficult for the receiver to recover data transmitted from several subcarriers. This issue has also been addressed in another study [10]. Thereby, the robustness of the system is reduced.

Some studies refer to emergency information systems designed upon the principles of deep learning [6, 14, 15, 17]. One of these studies underlines that although the emergency information systems designed upon the principles of deep learning work efficiently, they are not suitable for any type of emergency [6].

One study refers to emergency information systems that take advantage of smartphone capabilities, indicating the role of text messages as part of the emergency content [22]. The specific study clarifies that such emergency information systems work well in all types of emergencies, but the applications used should get access to full resources in Smart Phones.

Other studies underline the need for a more complex communication infrastructure, such as GIS systems [11, 12, 18]. Finally, one important study refers to DRM emergency information systems, indicating that they achieve a high maximum coverage percentage (99 approximately). However, the maximum coverage percentage drops in some cases and specifically after changing the antenna settings [8]. It is important to denote that the information is sent to a predetermined geographical area in case of the aforementioned emergency information systems. It is also essential to underline that one study stands out in the coverage prediction field, suggesting a way to predict the maximum coverage of a DRM emergency information system by considering specific antenna parameters [8]. This study also refers to the propagation models that could be generated by using specific software.

3. The Proposed System (UNIWA-EIS)

3.1. The Actual System

UNIWA-EIS is a DRM-based Emergency Information System that is developed to operate well in remote areas. The UNIWA-EIS doesn't use radio broadcast repeaters and achieves an affordable signal reception (no providers needed) [23, 24]. Our system is facilitated with fixed and mobile internet, as long as satellite internet. In addition, our system takes advantage of green power sources. A basic structure of the system is illustrated in Figure 1.

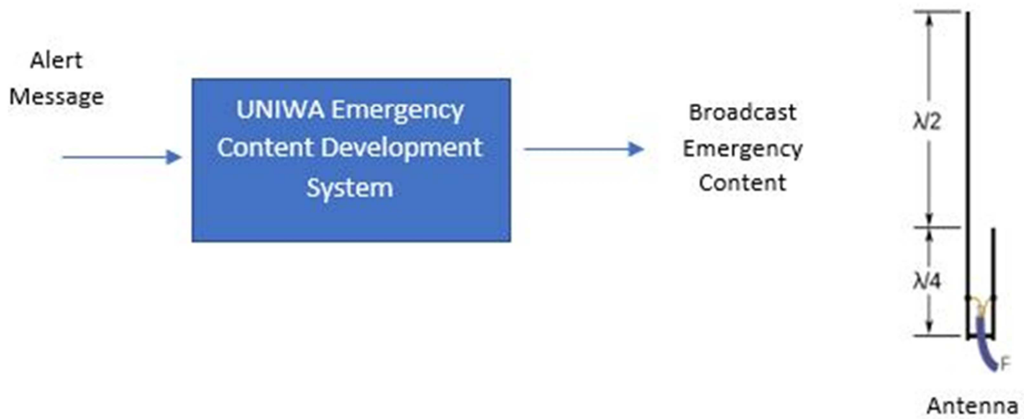

Figure 1. *The Actual System.*

The main UNIWA-EIS units are:

1) The UNIWA Emergency Content Development System: This system develops the appropriate Emergency Content according to the service that is activated. This process is in line with DRM Studio operation.
2) A specific antenna that complies with the standards of a j-pole antenna contributes to a rapid and accurate broadcast.

The robustness of our system lies in the fact that specific subsystems are put into action according to the algorithm depicted in Image 2. Section 3.2 clarifies the algorithm's functionality by demonstrating the experimental system.

3.2. The Experimental System

As it is depicted in Figure 2, the principal units of the experimental system are:

1) The Broadcast Model Selection System: It vouches for an accurate broadcast offsetting a possible loss of communication and a possible power outage. The Broadcast Model Selection System operates according to a specific algorithm that is illustrated in Figure 3.
2) The Remote Access Control System: It is responsible for the control of the broadcast mode selection operation and the control of the content development process.

Figure 2. *The Experimental System.*

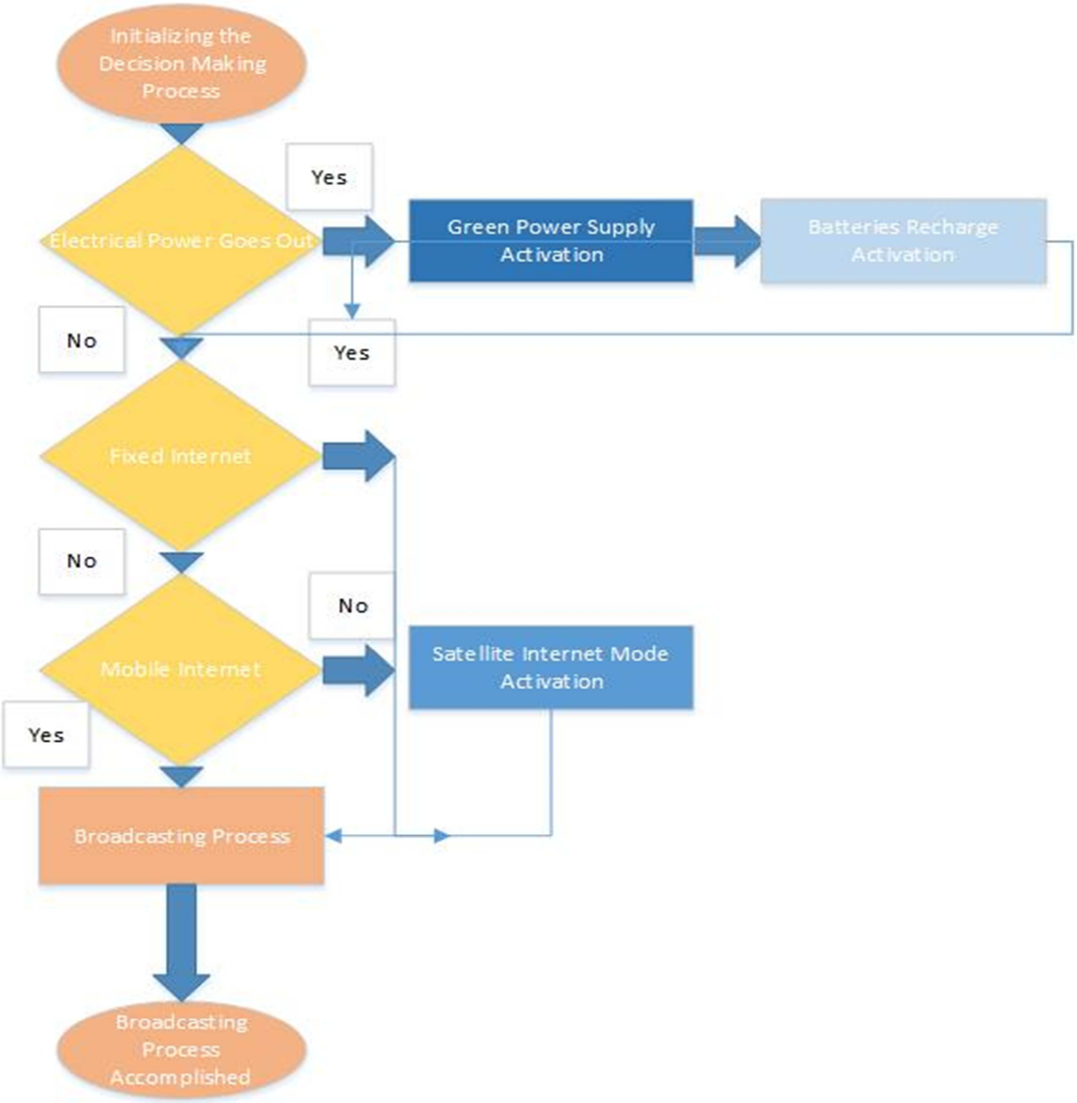

Figure 3. *The Broadcast Algorithm.*

This algorithm is used to select the appropriate broadcast mode in cases of communication loss and power outage. As it is illustrated in Figure 3, specific subsystems are activated according to the underlying algorithm. Practically, in case the electrical power goes out, a specific subsystem that takes advantage of alternative energy sources, such as solar power is activated. If the activation of the respective subsystem fails, a battery-recharge subsystem will be activated to ensure the effectiveness of the entire process.

In case the internet connection fails, another specific subsystem is activated. This system takes advantage of satellite internet capabilities. The subsystems are activated according to a specific order determined by the algorithm. This is proof of the algorithm's efficiency. Therefore, the broadcast of the emergency content doesn't fail.

4. Testing of the Proposed System

4.1. Method

Our research objective was to identify the maximum coverage of our system in areas with rough geographical terrain. For this purpose, our system came into effect in the mountainous region of Vigla, an area located on the island of Symi. LEGBAC methodology was used to serve this purpose. [25]. LEGBAC along with other similar methodologies provides maximum coverage results by analyzing parameters, such as site longitude, site latitude, transmitter power, and Carrier Wave Frequency [8]. The Signal Pro - EDX Wireless software was used to perform the requisite analysis.

Vigla is defined as the ‘Site’ in our case. In light of the previous study, we performed four (4) tests. Each test was different in terms of the antenna’s central frequency and signal strength. However, the transmitter power value was the same in all tests (977.24 watts).

It is essential to clarify that the LEGBAC methodology is not only used in coverage studies. It is also combined with prediction models to develop a coverage prediction framework [8, 25]. In detail, specific software could be used to combine the LEGBAC outcome with one of the prediction models to come up with the propagation model [8]. It is also important to point out that competent propagation models have been incorporated into various websites. However, in this case, the respective methodology has only been used to test the coverage of our system, paving the way for research expansion.

4.2. Experimental Results

Table 1 indicates that the field signal strength in the case of maximum coverage was 74.0 dBuV/m. The maximum coverage was achieved in the tests where the antenna central frequency value was 107.8 and 104.6 respectively. The following map (Figure 4) illustrates the field signal strength in the event of maximum coverage. It is important to underline that our system achieved great coverage in any antenna calibration, but the maximum coverage was achieved in the case of antenna vertical polarization.

Table 1. *Coverage Percentage.*

Signal Strength	Antenna Central Frequency	Antenna Polarization	Maximum Coverage Percentage
74.0	107.8	Vertical	99.7
66.0	93.3	Vertical	98.3
74.0	104.6	Vertical	99.2
66.0	88.2	Vertical	98.1

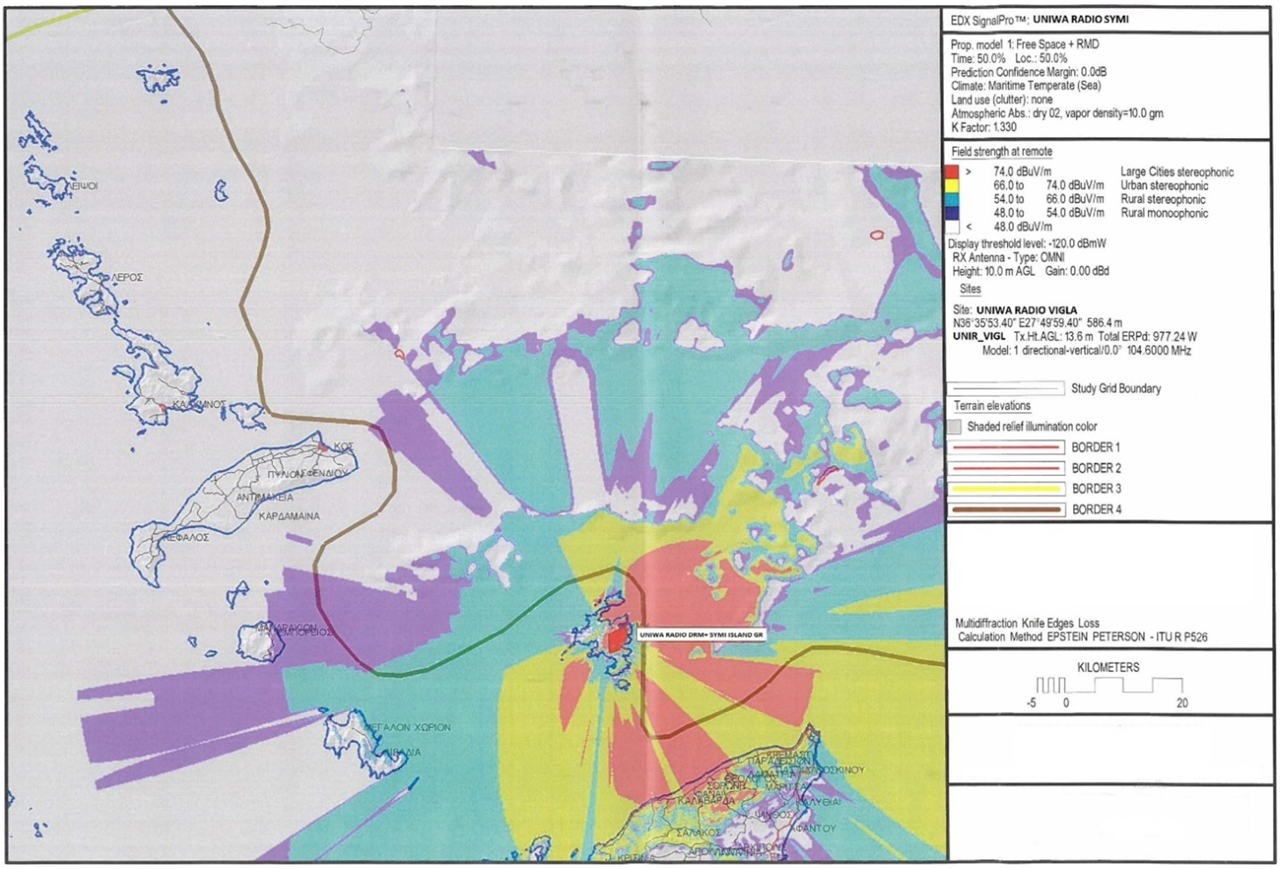

Figure 4. *Coverage Details.*

We also tested our system in various areas to come up with a wide-coverage map. Figures 5 and 6 depict our system's potential in these areas, indicating the field signal strength.

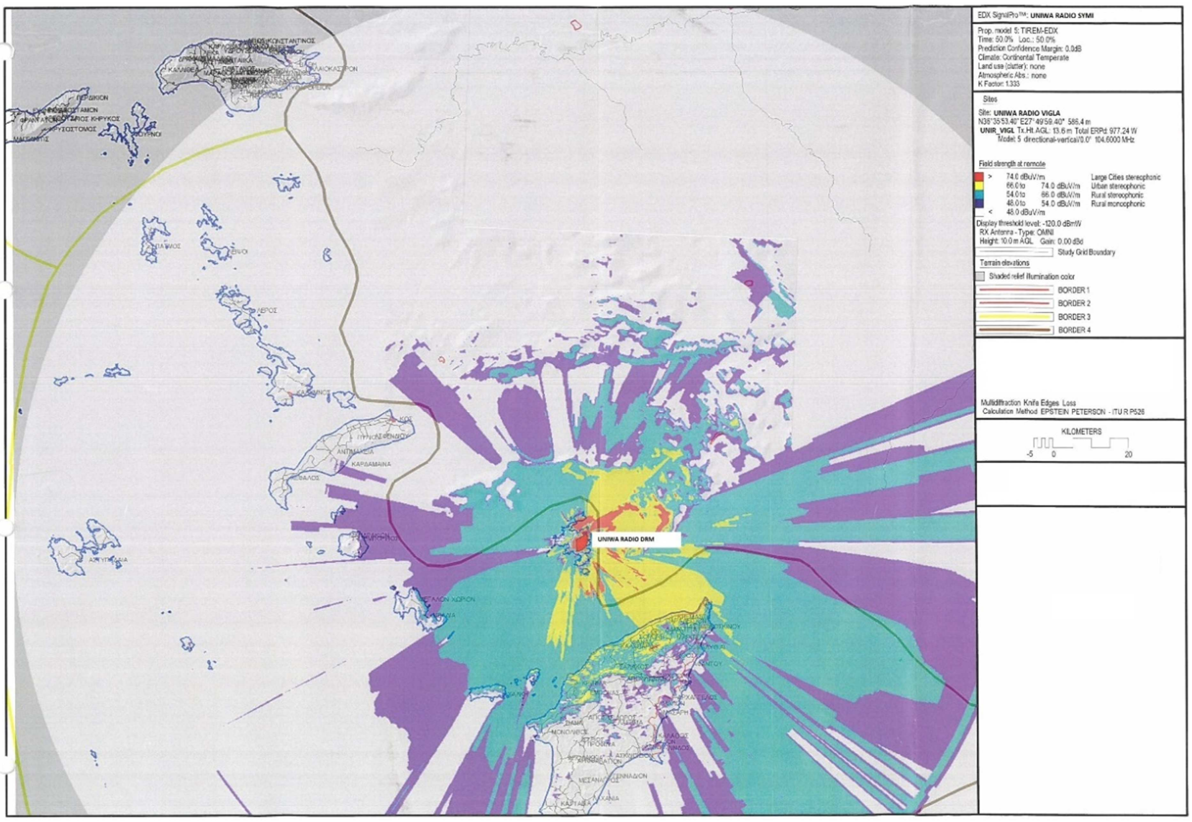

Figure 5. *Wide coverage map (part 1).*

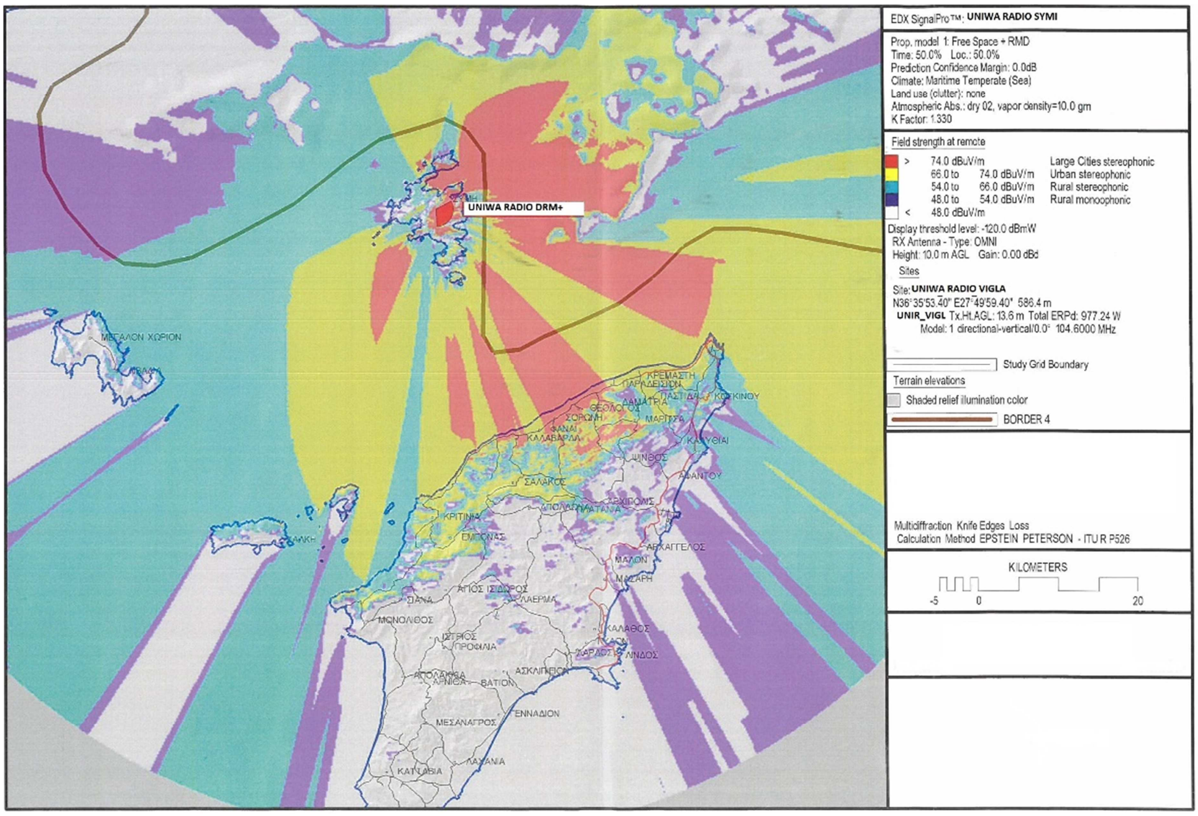

Figure 6. *Wide coverage map (part 2).*

As it is depicted in the wide coverage map, the field signal strength remained high in each area, indicating the high coverage potential of our system. Nevertheless, it is important to clarify that the geographical terrain in the testing areas was rough, indicating that our system achieves maximum coverage in areas with rough geographical terrain. It is also important to underline that Figure 5 illustrates the fluctuation of the field signal across the coverage range (distance from the transmitter) in each test area. Figure 5 indicates that the field signal strength dropped from 77.4 dBuV/m to 44.8 dBuV/m at a distance of 133 Km approximately.

5. Discussion

Our system achieved great coverage in any antenna setting (99% approximately) in contrast to typical DRM systems, the coverage percentage of which is affected by antenna calibration, and in most cases, it drops after changing the antenna settings [8]. Typical DRM systems do not work well in case of communication loss or power outage. Our system works well in these cases owing to the competent broadcast algorithm. Our system was tested and not only it worked well in these circumstances but also the coverage potential of our system remained high, indicating that our broadcast algorithm vouches for the best transmission outcome [26-29].

Additionally, as it has already been mentioned, the information is sent to a predetermined geographical area in most emergency information systems. The wide coverage map indicates that our system achieved a high coverage percentage in various areas, underlining the competency of our system. However, more tests are needed to argue that our system achieves high coverage percentage in all areas (even in areas with different geographical features). Though, our system appears to work well in areas with rough geographical terrain, a finding which is not mentioned in studies referring to DRM emergency information systems [8]. This is another proof of our system's robustness.

Finally, the field signal strength significantly dropped at a distance of 133 Km approximately, indicating a greater coverage range in comparison to one relative study in which the field signal strength appears to drop at 20 Km approximately and it also appears to slightly increase at 28 Km. It is also essential to denote that the field signal strength didn't exceed 59 dBuV/m in the respective study [30]. It is also important to clarify that the transmitter power was 977.24 watts in our case whereas the transmitter power was 300 watts in the DRM system mentioned in the underlying study. The increase in the transmitter power appears to account for our great coverage range. In fact, by analyzing the parameters properly in terms of the LEGBAC methodology, we came up with the optimal transmitter power to achieve a great coverage range. Therefore, the optimal transmitter power and the great coverage range constitute factors that point out our system's robustness compared to typical DRM systems.

6. Conclusion

This paper demonstrates a robust Emergency Information System that could be used to cover the need for information in remote areas with rough geographical terrain, offsetting a possible communication loss or power outage. The coverage potential of the system was not affected by antenna settings in contrast to typical DRM systems which are affected by antenna calibration. The subsystems added to the experimental system account for our system's robustness. Such subsystems could be integrated into a typical DRM Emergency Information System to increase transmission efficiency. The wide coverage map proved that our system works properly in various areas with the same geographical features. Therefore, our research could be expanded to come up with a coverage prediction model based on antenna calibration. Our team is currently working on generating a competent prediction model. The prediction model could be validated and it could potentially lead to a warning system that could deliver proper warning messages in case the maximum coverage percentage is predicted to be less than a predetermined threshold.

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