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The Influence of Environmental Noise Power on the Probability of Receiving GMDSS Alarm Signals

B. Uljasz
Military University of Technology, Warsaw, Poland

ABSTRACT: The article briefly presents the Global Maritime Distress and Safety System (GMDSS), which provides global emergency communication capabilities for maritime navigation through the use of satellite technologies (INMARSAT) and terrestrial VHF, MF, and HF frequency bands. In GMDSS-defined sea areas A3 and A4, particularly under conditions of severe satellite channel attenuation (greater than 100 dB), HF communication remains crucial. However, its effectiveness strongly depends on the signal-to-noise ratio (SNR), which may be significantly degraded by electromagnetic interference. The dominant noise source in the MF/HF range is man-made noise (MMN). ITU-R Recommendations and ITU-R Reports define standardized methodologies for noise measurement, including spectral analysis. Before installing a GMDSS station, and periodically during its operation, the interference environment must be assessed to ensure reliable reception of both voice and Digital Selective Calling alerts. The article presents a procedure for verifying changes in noise levels at the GMDSS antenna site.

1 INTRODUCTION

INMARSAT (GEO) is the most widely used maritime communication system between 70° south and 70° north latitude. GEO satellites do not provide coverage beyond these latitudes. Global communication beyond this range may be supported in the future by LEO satellite constellations such as Iridium, Starlink, or OneWeb; however, these are currently commercial systems with limited emergency applications. Under adverse weather conditions, satellite channel attenuation caused by the Earth's atmosphere can result in the complete loss of satellite communication, regardless of satellite orbit. Such attenuation may exceed 100 dB. Therefore, in emergencies involving severe atmospheric conditions, terrestrial communication in the VHF, MF, and HF bands is employed. The VHF band enables communication over several tens of kilometers, MF during daytime up to approximately 150 km, while nighttime MF and the HF band support continuous long-range communication when ships are beyond the range of VHF and daytime MF coverage.

Communication below 30 MHz (MF/HF) is particularly vulnerable to ambient noise at the receiver antenna site. Improper selection of a GMDSS station location may result in the inability to receive emergency signals in the MF and HF bands due to insufficient signal-to-noise ratio (SNR). Analyzing the noise power at a proposed GMDSS station site increases the likelihood of successful reception of distress alerts. Periodic verification of the surrounding infrastructure is recommended due to potential increases in man-made noise resulting from technological development. Variations in noise power between sites can exceed 20 dB, which corresponds to more than a hundredfold increase in transmitter power. This article presents a verification procedure for evaluating GMDSS station locations in terms of noise interference.

The Global Maritime Distress and Safety System (GMDSS) [1–5] is designed for transmitting maritime safety and distress alerts over large bodies of water using high-frequency (HF) communication. The speed and effectiveness of rescue operations and, consequently, the ability to save human lives or mitigate environmental damage caused by maritime disasters often depend on the error-free exchange of information.

Locating GMDSS coastal stations in areas with high noise levels reduces the probability of successful distress signal reception. Therefore, the proper selection of station locations and their periodic verification with respect to ambient noise background becomes a critical factor in maintaining system reliability.

Noise and interference in radio communications have a detrimental effect on the ability to correctly receive desired signals.

In high-frequency (HF) communications, the dominant noise sources are typically man-made. Human infrastructure has a significant impact on the ambient noise level in this frequency range [6].

However, the level of man-made noise is less dependent on population density and more closely related to the technological sophistication of local infrastructure. Power supplies of certain lighting systems, electric motor startups, generators, switch-mode power supplies, and large-scale data centers can substantially elevate local noise levels. As a result, during peak operational hours, noise levels may significantly exceed acceptable limits defined by international standards.

Due to the continuous development of infrastructure and the increasing technological complexity, even in previously low-noise areas, periodic noise assessments at GMDSS station sites are justified and necessary.

2 GMDSS

The Global Maritime Distress and Safety System (GMDSS) entered into force on February 1, 1992, and reached full operational capability on February 1, 1999 [1-5].

The primary objective of GMDSS is to organize all communications related to maritime safety and distress into a unified and structured framework. The system was initiated by the International Maritime Organization (IMO), in cooperation with the International Hydrographic Organization (IHO), the World Meteorological Organization (WMO), and the International Maritime Satellite Organization (INMARSAT).

Initially, GMDSS aimed to develop effective system-level, organizational, and legal solutions to ensure proper maritime safety, with particular emphasis on reliable and timely distress alerting methods. This, in turn, was intended to enhance the responsiveness and efficiency of search and rescue operations. Based on years of observations, experience from numerous rescue missions, and analysis of distress alert procedures, a set of operational assumptions was developed. These assumptions now form the basis for the functioning of the modern GMDSS.

The core assumptions of the system include:

- widespread adoption and use of satellite-based positioning and localization systems,
- high-frequency (HF) radio communication based on the Single Side Band (SSB) system,
- radioteletype (RTTY) communication adapted for error detection and correction,
- data exchange using Digital Selective Calling (DSC) in terrestrial communications across the Very High Frequency (VHF), High Frequency (HF), and Medium Frequency (MF) bands.

For operational purposes, the GMDSS divides maritime waters into four sea areas. This division is based on the effective communication range of various radio technologies and equipment installed on vessels. Accordingly, the GMDSS defines sea areas A1, A2, A3, and A4.

Sea area A1 is defined as the area within coverage of at least one VHF coast station that provides continuous and reliable distress alerting using a VHF radiotelephone equipped with a Digital Selective Calling (DSC) controller, typically within a range of up to 30 nautical miles.

Sea area A2 is the area outside sea area A1, but within the coverage of at least one MF coast station capable of distress alerting using DSC on the frequency 2187.5 kHz, typically extending up to 150 -200 nautical miles from the coast station. Vessels operating in this area are also required to carry the same equipment as for sea area A1.

Sea area A3 encompasses the regions between 70 degrees north and 70 degrees south latitude. Within this area, satellite communication coverage via the INMARSAT system is available. Vessels operating in this region are required to be equipped with either an HF radio with a DSC controller or an INMARSAT terminal. Additionally, they must carry the same communication equipment as required for sea areas A1 and A2. Furthermore, vessels must be equipped to receive Maritime Safety Information (MSI) relevant to sea area A3, either via Enhanced Group Call (EGC) through INMARSAT or via HF radio telex.

Sea area A4 includes all maritime regions outside sea areas A1, A2, and A3. Due to the lack of INMARSAT satellite coverage in these high-latitude regions (beyond the coverage of geostationary satellites), vessels operating in sea area A4 must be equipped with an HF radio fitted with a DSC controller. They are also required to carry all equipment specified for sea areas A1, A2, and A3.

Regardless of the sea area, every maritime vessel must be equipped with a 406 MHz Emergency Position Indicating Radio Beacon (EPIRB) and a Search and Rescue Radar Transponder (SART) for localization and guidance to the distress site.

Digital Selective Calling (DSC) distress alerts in sea areas A3 or A4, transmitted in the MF/HF bands, may be sent on one to six designated distress frequencies.

Table 1. Distress Frequencies in the MF/HF Bands

No.	Band	Frequency
1	MF	2 187.5 kHz
2	HF	4 207.5 kHz
3		6 312.0 kHz
4		8 414.5 kHz
5		12 577.0 kHz
6		16 804.5 kHz

Figure 1 illustrates the transmission method of distress alerts as a sequence of up to six consecutive call attempts, each transmitted on a different designated distress frequency, one in the MF band and up to five in the HF bands.

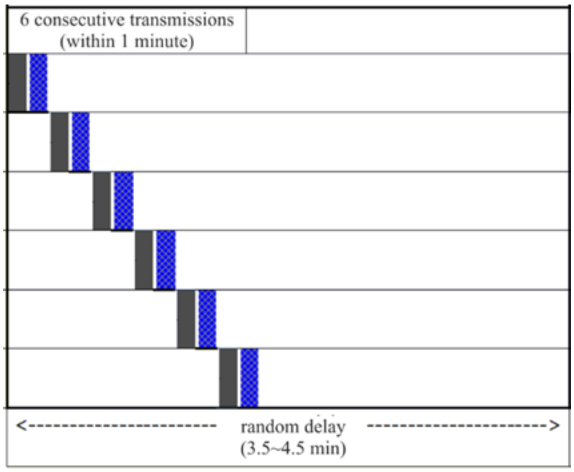

Figure 1. GMDSS DCS Multi-frequency call attempts [3] black – Basic distress alert message; blue – Expansion message (Rec. ITU-R M.821) (Message Initial transmission from one station and identical Automatic retransmission message from two stations)

Distress alerts in the VHF band may be transmitted simultaneously with alerts in the MF/HF bands. Stations transmitting multi-frequency distress call attempts in the MF/HF bands must be capable of continuously monitoring for acknowledgments on all frequencies used except for the one currently transmitting, or must be able to terminate the call attempt within 1 minute.

Multi-frequency call attempts may be repeated after a random delay of between 3.5 and 4.5 minutes from the start of the previous attempt.

For the transmission of digital DSC distress signals in the HF and MF bands, F1B or J2B modulation is used, with a frequency shift of 170 Hz and a symbol rate of 100 baud [2]. In the case of J2B modulation, the baseband signal is modulated onto a 1700 Hz subcarrier.

According to Table 1 in Annex 1 of Recommendation ITU-R F.339, for the above signal parameters, the required signal-to-noise ratio (SNR) for DSC transmission is 43 dB/Hz in a stable channel or 52 dB/Hz in a fading channel [2].

During adverse weather conditions, satellite channel attenuation caused by the Earth's atmosphere can result in the complete loss of satellite communication, regardless of the satellite's orbital position. Such attenuation can exceed 100 dB. Therefore, in emergencies, particularly in sea areas A3 and A4 under severe weather, ionospheric communication in the HF band is utilized.

However, HF communication is not only affected by ionospheric variability (primarily driven by solar activity), but also by ambient noise at the receive antenna location. Improper selection of a GMDSS station site may lead to the inability to receive distress signals in the HF band. The signal-to-noise ratio (SNR) at such locations may fall below the threshold required for error-free message reception.

Conducting noise power analysis at a proposed GMDSS station site significantly increases the probability of successful reception of Digital Selective Calling (DSC) signals. Periodic verification of the station's surrounding infrastructure is also recommended due to increasing urban noise levels. Differences in noise power between locations may exceed 20 dB, which corresponds to more than a hundredfold increase in transmitter power.

The final part of the article presents a procedure for evaluating GMDSS antenna locations with respect to noise interference.

3 SOURCES OF RADIO NOISE

Radio noise may originate from both natural and man-made sources. According to the definition provided in ITU-R Recommendation P.372 [6], radio noise is the aggregate of emissions from multiple sources that are not intentional radiocommunication transmitters. When no single dominant noise source is present at a measurement location, the statistical amplitude distribution of the radio noise often follows a normal distribution and may be considered Gaussian white noise.

However, due to the high density of noise-emitting devices, especially in urban and residential areas, it is practically impossible to find a location that is not at least intermittently dominated by emissions from one or more specific sources. These sources frequently generate impulsive signals or single-carrier emissions. Since radiocommunication equipment must operate within such environments, excluding these components from radio noise measurements may be unrealistic.

According to [12], radio noise consists of three main components: White Gaussian Noise (WGN), Impulsive Noise (IN), and Single Carrier Noise (SCN).

White Gaussian Noise (WGN) is characterized by the following properties:
- Uncorrelated electromagnetic field vectors
- Bandwidth equal to or greater than the receiver bandwidth
- Spectral power level increases linearly with bandwidth

Typical sources of this type of noise include: computers, power line communication networks, wired computer networks, and cosmic background noise.

Impulsive Noise (IN) is characterized by the following properties:

– Correlated electromagnetic field vectors
– Bandwidth greater than the receiver bandwidth
– Spectral power level increases proportionally to the square of the bandwidth

Typical sources of this type of noise include: ignition sparks, lightning discharges, gas lamp starters, computers, and ultra-wideband (UWB) devices.

Single Carrier Noise (SCN) is characterized by the following properties:
– One or more distinct spectral lines
– Bandwidth narrower than the receiver bandwidth
– Spectral power level independent of the receiver bandwidth

Typical sources of this type of noise include: wired computer networks, computers, and switch-mode power supplies.

While the WGN component can be sufficiently characterized by its root mean square (RMS) value, this is significantly more challenging for impulsive noise (IN). Modern digital communication services almost always employ error correction mechanisms, making them more resilient, particularly to impulsive disturbances. However, when impulse durations and repetition rates exceed certain thresholds, IN can severely degrade system performance.

Therefore, it is desirable to measure radio noise in a manner that not only quantifies the level of IN but also provides statistical information about the distribution of impulse parameters.

Single Carrier Noise (SCN) is identified as such only when it originates from a single source located near the measurement site. When multiple single-carrier sources are present, their emissions quickly combine into a noise-like spectrum as their number increases. ITU-R Recommendation P.372 [6] defines radio noise as the aggregate of unintentional emissions from various sources and explicitly excludes emissions from single, identifiable sources.

Therefore, it is essential to select measurement locations or frequencies that are not dominated by emissions from such individual sources. As a result, further consideration of SCN is not necessary in the context of man-made noise (MMN) measurements.

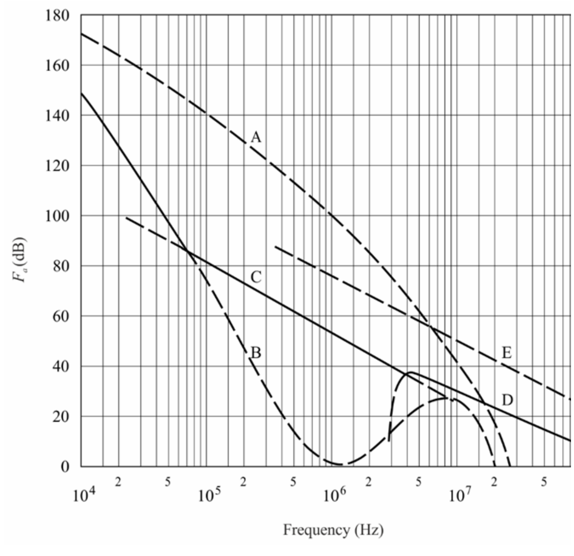

Figure 2. Noise characteristics for the frequency range from 10 kHz to 100 MHz across different noise categories

This frequency range encompasses several noise sources, each with distinct spectral characteristics. According to ITU-R Recommendation P.372, the main categories include:
A – Atmospheric noise (value exceeded 0.5% of the time)
B – Atmospheric noise (value exceeded 99.5% of the time)
C – Man-made noise (quiet receiving site)
D – Galactic noise
E – Median city area man-made noise

Additionally, the solid reference curve provided in the ITU-R documentation represents the minimum expected noise level under ideal receiving conditions.

These characteristic curves serve as a reference for evaluating background noise levels across different environments and are fundamental for assessing the suitability of HF/MF receiving sites, particularly for safety-critical systems such as GMDSS.

The solid line largely coincides with curve C, which represents the minimum level of man-made noise (MMN) at a quiet receiving site. In contrast, the maximum noise levels observed most of the time are described by curve E, corresponding to typical MMN levels in urban environments.

This indicates that man-made noise (MMN) is the dominant noise source in the MF/HF bands for the majority of the time, particularly in populated and industrialized areas. This conclusion is critical when assessing receiver site suitability and ensuring reliable radio communication in these frequency ranges.

Table 2. Significant Sources of Radio Noise by Frequency Range [12]

Noise Source	Frequency Range
Atmospheric noise (lightning discharges)	9 kHz - 30 MHz
Galactic (cosmic) noise	4 MHz - 100 MHz
Man-made noise	9 kHz - 1 GHz

These sources may overlap, and the dominant noise component depends on the intensity and proximity of the sources relative to the measurement location. In most environments, man-made noise (MMN) is the prevailing contributor in the MF/HF frequency bands.

Man-made noise may also consist of a combination of the aforementioned categories. The dominance of a specific noise type depends on the intensity of the sources and their spatial proximity to the observation point.

Man-made Additive White Gaussian Noise (AWGN) typically occurs when numerous individual sources of similar strength are located at a significant distance from the receiver. In contrast, the presence of Single Carrier Noise (SCN) indicates one nearby source or a limited number of proximate sources. The former scenario is more common in outdoor environments, while the latter is typical of indoor settings.

Natural noise sources tend to remain relatively stable over long periods. However, man-made noise (MMN) can dominate specific portions of the radio spectrum, and its intensity fluctuates in response to increases in the number of electrical and electronic devices, the introduction of new technologies, and advancements in electromagnetic compatibility (EMC) practices. Therefore, in radio noise measurements used to assess site suitability, particular attention must be paid to man-made noise.

Median values of the AWGN noise factor for various typical outdoor environments are shown in Figure 3, which also includes the galactic noise curve.

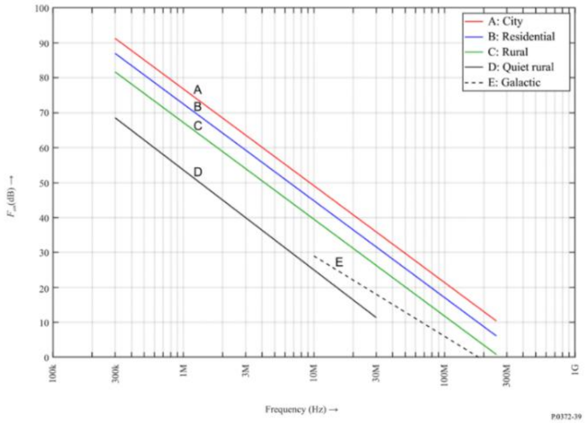

Figure 3. Median values of man-made noise power for a short vertical lossless grounded monopole antenna [6]

In all cases, the results conform to a linear variation of the median noise factor, Fam, expressed in dB, as a function of frequency f, in the following form [6]:

$$F_{am} = c - d \log f \quad (1)$$

where:
F_{am} - is the median external noise factor [dB],
f - is the frequency [MHz],
c and d - are constants dependent on the environmental category.

When f is expressed in MHz, the constants c and d take the values listed in Table 3.

Table 3. Values of the constants c and d for Different Environmental Categories [6]

Environmental category	c	d
City (curve A)	76.8	27.7
Residential (curve B)	72.5	27.7
Rural (curve C)	67.2	27.7
Quiet rural (curve D)	53.6	28.6
Galactic noise (curve E)	52.0	23.0

It should be noted that Equation (1) is valid across the entire MF/HF range for all environmental categories except for curves D and E, as shown in the figure.

Curve D represents man-made noise reflected by the ionosphere and is observed below the extraordinary critical frequency of the ionosphere (*fxF2*), which varies depending on the time of day, season, and the solar cycle.

Above *fxF2*, the ionosphere gradually becomes transparent, and galactic noise becomes the dominant component, as represented by curve E.

4 IMPACT OF INDUSTRIAL NOISE LEVELS

Industrial noise levels have a significant influence on the reliability and availability of radiocommunication links, particularly in the MF and HF bands used by systems such as GMDSS. Elevated ambient noise, typically present in industrial or urban environments, directly reduces the signal-to-noise ratio (SNR), which is a critical parameter for the correct reception of Digital Selective Calling (DSC) and other safety-related transmissions.

Increased electromagnetic emissions from equipment such as motors, power converters, industrial lighting, and data processing centers contribute to higher man-made noise (MMN) levels. This not only decreases the effective communication range but also raises the probability of reception errors or complete loss of signal detection.

As demonstrated in prediction models [7-10, 17] and field measurements, even a moderate increase in ambient noise, on the order of 10 to 20 dB, can drastically reduce the time availability of links meeting required SNR thresholds. Therefore, minimizing industrial noise influence through proper site selection and periodic monitoring is essential for maintaining reliable GMDSS performance.

This section of the article presents sample characteristics illustrating the impact of ambient noise levels at the receiver antenna location on the probability of successful DSC signal reception.

a)

b)

c)

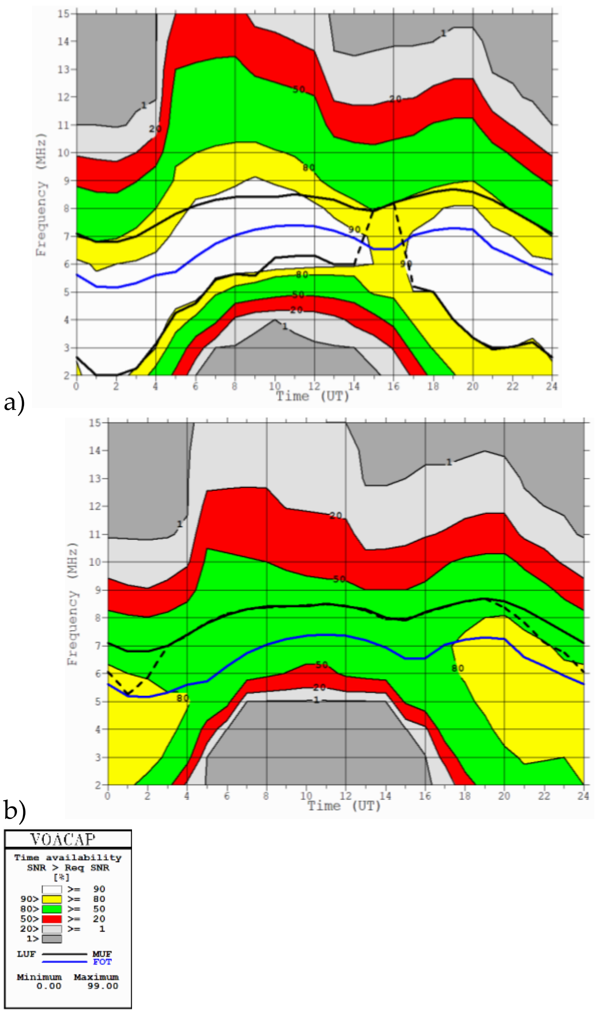

Figure 4. Time availability of SNR values exceeding the required threshold and the LUF curve [17]: a) Remote environment [6], b) Industrial environment [6], c) Scale indicators used in Figures a and b

Figures 4 through 6 show the results of a prediction for Time Availability where SNR > Required SNR (43 dB). The prediction was conducted for a communication scenario in June 2025, with a sunspot number (SSN) of 108, a Power transmitter of 100 W, and a distance of 564 km between the transmitting and receiving stations. The required SNR for reliable reception was set to 43 dB/Hz.

These plots illustrate how different noise environments affect the availability of sufficient signal-to-noise ratio (SNR) for reliable reception, in conjunction with the Lowest Usable Frequency (LUF) curve. The comparison highlights the reduced time availability in higher-noise (industrial) environments, where elevated background noise levels limit effective HF communication performance.

Based on the information presented in Figure 4, a significant decrease in the probability of correct reception of GMDSS DSC signals can be observed at a receiving site with a higher environmental noise level (a difference of 13.56 dB/Hz), despite identical transmitter power and ionospheric conditions.

This emphasizes the critical influence of ambient noise on HF communication reliability and the necessity of careful site selection for GMDSS receiving stations.

This scenario represents a low-noise environment, typically corresponding to a remote or quiet rural area. Under these conditions, the probability of establishing and maintaining a reliable HF communication link at 8414 kHz is high, assuming standard ionospheric propagation and system parameters. The low ambient noise level significantly improves the signal-to-noise ratio (SNR), increasing the likelihood of successful reception of Digital Selective Calling (DSC) signals and other critical communications.

This case illustrates communication performance in a high-noise environment, such as an industrial or urban area. The significantly elevated ambient noise level (by approximately 23.6 dB compared to a quiet site) leads to a substantial reduction in the signal-to-noise ratio (SNR). Consequently, the probability of successful communication at 8414 kHz decreases markedly, increasing the risk of failed reception of Digital Selective Calling (DSC) alerts and other safety-critical transmissions. This highlights the critical importance of proper site selection for GMDSS receiving stations.

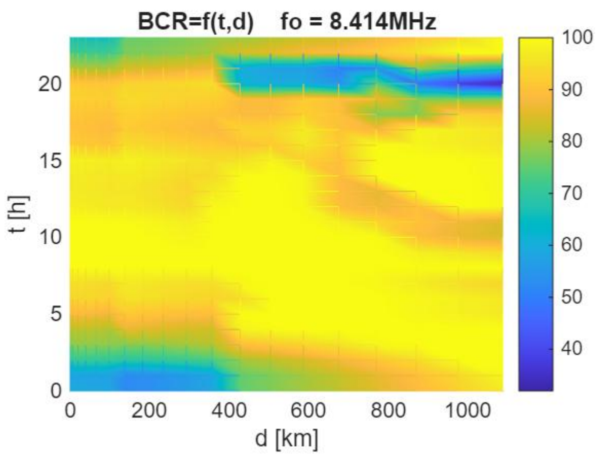

Figure 5. Probability of communication at 8414 kHz in an environment with a noise level of 164 dBW/Hz

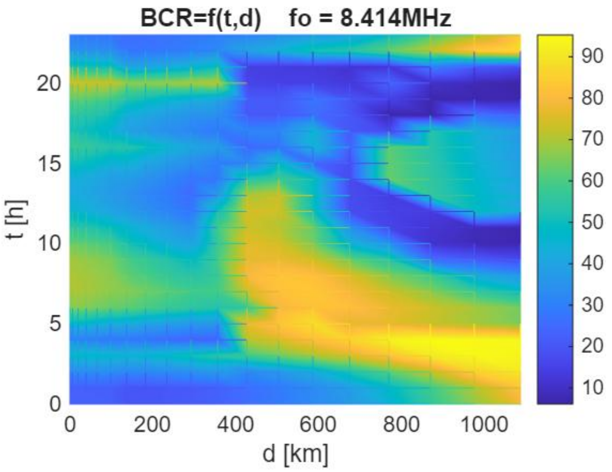

Figure 6. Probability of communication at 8414 kHz in an environment with a noise level of 140.4 dBW/Hz

Figures 5 and 6 present the probability of establishing communication, expressed as a percentage. The figures were generated using a custom application developed based on [7] and validated against the results produced by publicly available tools [8–10].

5 RADIO NOISE MEASUREMENT PROCEDURES

According to ITU-R guidelines SM.1753 [12], SM.2055 [13], SM.2155 [4], and SM.2157 [15], radio noise measurement procedures consist of several key stages that ensure the reliability and repeatability of results:

– Choosing an appropriate measurement location is essential for obtaining representative results. In line with ITU-R recommendations (particularly SM.2155), the site should reflect the characteristics of the investigated environment: urban, rural, or remote. It is recommended that the location not be near strong local interference sources (e.g., high-voltage power lines, industrial machinery), which could distort the recorded noise levels.
– Wideband receivers or spectrum analyzers compliant with ITU-R SM.2055 specifications must be used. Prior to recording, careful calibration of the measurement system is required. Calibration should be performed using known reference signal sources according to SM.2055 procedures to ensure data accuracy and repeatability.
– Antennas used for measurement must have radiation patterns suitable for the observed frequency range (e.g., HF: 3-30 MHz). As per SM.2157, the antenna should be installed at a height that minimizes reflections from the ground and surrounding objects. The measurements must be conducted under conditions that ensure signal reception is stable and repeatable within the designated band.
– The measurement procedure involves recording noise levels at selected frequency points. According to ITU-R SM.1753, the spacing between measurement points on the frequency axis should be no less than 0.05 decades to obtain a detailed interference profile over the full measurement range. Results are recorded for a defined detection bandwidth, most commonly 9 kHz or 10 kHz. Observation time at each frequency point should be

sufficient to average signal fluctuations, typically ranging from several to a dozen minutes per point.
- Collected data is subjected to statistical analysis to determine average, maximum, and minimum noise levels for each frequency and location. Results should be presented in graphical form, showing the relationship between interference levels, frequency, and measurement site, following SM.2155 guidelines. The measurement report must include a description of the methodology used, equipment configuration, environmental conditions, and detailed numerical and graphical results to allow comparison with other studies or international standards.
- Recommendation SM.2157 also emphasizes the need to document all factors that may influence noise levels under specific measurement conditions, such as weather, presence of atypical emission sources, or environmental changes. The final report should include both numerical data and detailed descriptions of the measurement context.
- Adhering to the aforementioned ITU-R recommendations and reports ensures the reliability, comparability, and high quality of radio noise measurement results, which are essential for assessing the electromagnetic environment and planning future radiocommunication infrastructure deployments.

6 RADIO NOISE MEASUREMENT PROCEDURE FOR THE GMDSS SYSTEM

The development of infrastructure in the vicinity of GMDSS stations, particularly those operating in the MF/HF bands, should be monitored by national and international authorities. Before selecting an installation site, a comprehensive assessment of the noise characteristics at the proposed location must be conducted. Periodic verification measurements should also be performed, with particular attention to noise originating from human activity.

The standard procedure for assessing site suitability with respect to noise is described in Section 3. However, considering the specific operational characteristics of the Global Maritime Distress and Safety System (GMDSS), this procedure may be simplified to significantly reduce the time required for measurements and subsequent data analysis.

A simplified measurement procedure is presented below, based on guidelines from [12–16].

6.1 *Procedure for Periodic Verification*

To ensure the long-term reliability of GMDSS stations operating in MF/HF bands, the following simplified procedure is recommended for periodic noise level verification at the station site:
- Conduct measurements at the GMDSS station location.
  Measurements must be performed directly at the operational site of the GMDSS system to reflect the actual electromagnetic environment affecting signal reception.
- Use standard GMDSS receiving equipment.
  The measurements should utilize the standard receivers installed as part of the GMDSS setup, ensuring relevance and operational representativeness.
- Use the GMDSS receiving antennas.
  Antennas normally used by the system should be employed, maintaining consistent reception characteristics and eliminating the influence of differing antenna parameters.
- Record signals in the working frequency bands of the GMDSS system.
  Measurement should be performed in the vicinity of operational frequencies to assess real-world interference in channels actively used for communication and distress alerts.
- Select interference-free radio frequencies
  Prior to measurements, a spectral analysis must be conducted around each GMDSS working frequency (±50 kHz) to identify at least m noise-only measurement frequencies, those free from intentional emissions (e.g., broadcast, communication, radar signals). These frequencies should contain only natural and unintended man-made noise.
- Measure electromagnetic field strength at each selected frequency
  Use RMS and AVG detectors to measure the electric field strength. The RMS values are used to compute absolute levels, while AVG values support statistical deviation analysis. For each measurement frequency: (2):

$$E(f) = U_{RMS}(f) + AF(f) - A(f) \tag{2}$$

where:
E(f) – field strength at frequency f [dBμV/m]
$U_{RMS}(f)$ – RMS level measured by the receiver [dBμV]
AF(f) – antenna factor [dB/m]
A(f) – cable attenuation [dB].
- Calculate the external noise factor for each frequency

$$Fa(f) = E(f) - 20log_{10}(f) + 95.5 - 10log_{10}(B) \tag{3}$$

where:
Fa(f) – external noise factor [dB]
f – frequency [MHz]
B – receiver bandwidth [Hz]
- Determine the median noise factor and confidence interval
  For each measurement frequency, calculate the median of the n measured Fa(f) values and determine the confidence interval encompassing at least 90% of observations. Present the results graphically.
- Calculate the deviation of the signal level

$$Vd(f) = U_{RMS}(f) - U_{AVG}(f) \tag{4}$$

where:
Vd(f) – signal level deviation [dB]
$U_{RMS}(f)$ – RMS value [dBμV]
$U_{AVG}(f)$ – average value [dBμV]
Repeat statistical analysis for *Vd(f)* across all n values to determine the confidence interval and plot the results.
- Evaluate site suitability
  Based on *Fa(f)* and *Vd(f)* values:

The site is suitable if *Fa(f)* does not exceed the reference "quiet rural" level by more than 3–4 dB, and *Vd(f)* during daytime does not exceed 3 dB.

- Document environmental factors
  The final report must include all factors that could influence the measurement (e.g., weather, solar conditions, nearby emitters).
- Prepare comprehensive documentation including:
  - General info (site, date, operator)
  - Equipment setup (antenna, receiver, analyzer, calibration)
  - Measurement parameters (frequency range, bandwidth, time)
  - Environmental conditions (temperature, humidity, power supply)
  - Raw data and processed results
  - Graphs, spectrograms, photos, and data files

This procedure provides a reliable and efficient method for monitoring the electromagnetic noise environment around GMDSS installations, ensuring their ongoing readiness for distress alert reception.

7 CONCLUSIONS

The effectiveness of GMDSS communication in the MF and HF bands depends significantly on the level of local electromagnetic noise, which in urban environments may reduce the signal-to-noise ratio (SNR) below the threshold required for error-free reception of DSC distress signals.

The dominant source of interference in the below 30 MHz band is man-made noise (MMN), the level of which can vary by more than 20 dB depending on the receiving station's location. This corresponds to a change in transmitter power of more than two orders of magnitude.

Proper selection of GMDSS station sites should be preceded by noise characterization measurements in accordance with ITU-R recommendations (P.372, SM.1753, SM.2055, SM.2155, SM.2157), using spectrum analyzers, RMS/AVG detectors, and measurement antennas with suitable directional characteristics.

Periodic verification of radio noise levels at the GMDSS station site is essential due to ongoing infrastructure development, which increases impulsive noise (IN) and single carrier noise (SCN), especially as urbanization and electromagnetic emissions grow.

Applying a simplified site evaluation procedure using the existing GMDSS infrastructure (antennas and receivers) enables effective monitoring of changes in radio noise without the need to expand the measurement setup, while maintaining adequate accuracy.

Measurement results should be analyzed statistically, taking into account the median external noise factor *Fa(f)* and signal level deviation *Vd(f)*. This allows for an objective evaluation of the electromagnetic environment's quality in the context of distress communication reliability.

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