International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Wireless Channel Models for Marine Communication

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DOI: https://doi.org/10.55248/gengpi.5.0324.0770

ABSTRACT—

Owing to the blue economy's explosive expansion, broadband maritime communication is crucial. In contrast to MF/HF/VHF pathways, there has been a rise in interest for utilizing higher frequency bands to provide broadband information service to the sea area.The two primary channel types for an air-ground-sea communications network are air-to-sea (for communication linkages from aircraft-based base stations or relays, for example) and near-sea surface (for land-to-ship/ship-to-land or ship-toship communications). Modelling these maritime channel links is different from modelling conventional terrestrial wireless channels in many ways, which will have a major influence on the transceiver because of the unique characteristics of the maritime propagation environment, such as sparse dispersion, sea wave behaviour, and the ducted effect over the sea surface. Finally, we highlight the most significant deviations from the modelling and the channel properties for the channel linkages between the air and the sea and the near-sea surface.

Keywords— sea wave behaviour, ducted effect, and sparse dispersion

1. INTRODUCTION

In order to comprehend and create communication systems that function in the maritime environment, wireless channel models are crucial for marine communication. Marine communication entails the sharing of data in order to improve operational coordination, safety at sea, and navigation between ships, shore stations, and other maritime entities. The development of industries like fishing, tourism, oil exploitation, transportation, and environmental monitoring has led to a notable surge in the maritime sector in recent decades. Higher data rates and reliable wireless communication are essential for these industries. Maritime communication systems that use the MF/HF/VHF bands include navigational telex (NAVTEX), automatic identification systems (AIS), and VHF data exchange systems. The air-to-sea channel link, which is used for transmission from aircraft-based BSs or relays, and the near-sea-surface channel link, which is used for land-to-ship, ship-to-land, and ship-to-ship communications, comprise the near coast integrated air-ground-sea communication network. These models consider variables like the signal's frequency, the weather, and the separation between the vessels. Additionally, 5G technologies like user-centric networks, massive multiple-input multiple-output (MIMO), and millimeter -wave (mm Wave) have the potential to offer widely dispersed maritime users a higher data rate coverage. This survey, give a comprehensive overview of the current modelling techniques and measurement outcomes for the maritime wireless channel and to draw attention to its main distinctions from the channel models that are frequently used for terrestrial communications.

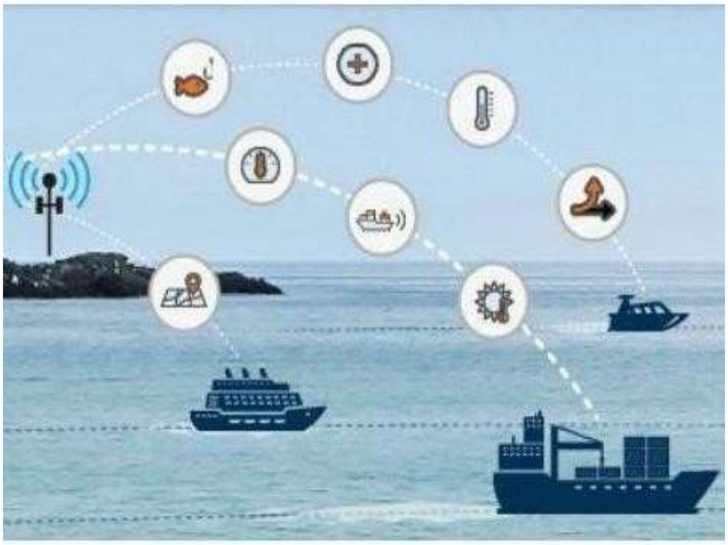

Fig 1: A survey on enabling technologies in marine communication

Maritime wireless channels are distinguished by two characteristics: instability and location dependence. The instability feature is noticed. The location dependent feature suggests that completely different model structures for the channels in various location regions should be applied for a maritime user. These characteristics present new possibilities and challenges for the design of upcoming marine communication systems. The maritime industry's demand for increased safety, efficiency, and connection has propelled advancements in marine communication. Taken together, these characteristics in the quickly developing field of marine communication improve safety, navigation, and operational effectiveness in the maritime sector

TABLE 1: **Features of marine communication**

S.NO	FEATURES	CHARACTERISTICS
1	Interoperability	Long Range
2	Voice Integration	VHF Radio
3	Standardization	GPSS
4	Data integration	Weather Influence

II. HISTORY

The evolution of wireless channel communication in marine systems has occurred over several decades, with substantial technological and communication protocol advances. Wireless communication in the maritime industry dates back to the late nineteenth century, with the introduction of radio telegraphy. Guglielmo Marconi is credited with successfully transmitting the first wireless signals across vast distances, which led to the development of the first operational wireless communication systems. The early twentieth century saw the expansion of wireless communication to incorporate speech transmission, ushering in marine radiotelephony. This advancement dramatically increased communication between ships and shore stations, hence increasing maritime safety and coordination. Modern technology is largely shaped by the history of marine communication, making maritime operations safer and more effective. In 1988, the International Maritime Organization (IMO) launched a Worldwide The maritime sector Alert and Rescue Network. GMDSS combines a variety of communication technologies, including satellite communication, VHF, MF/HF radiotelephony, and digital selective calling (DSC), to provide quick and effective communication in crises. Modern marine communication systems are becoming more integrated with modern bridge systems. This integration incorporates a variety of communication tools, navigation equipment, and connectivity solutions, resulting in a holistic approach to marine communication and navigation. During past times, the goal has been to improve maritime safety, routing, and coordination by developing and deploying advanced wireless communication technology. The marine business is constantly evolving, embracing new innovations to suit the expanding demands of global shipping and navigation.

III. CLASSIFICATION

The categorization of marine communication can be achieved by considering the objectives, modes of communication, and available technologies.

1) **Purpose-Based Classification:**

a. **Navigation Communication:** Covers communication pertaining to safe vessel movement and navigation, including course corrections, position reporting, and collision avoidance.

b. **Safety Communication:** Describes messages pertaining to safety, urgency, and distress, such as alerts and emergency calls.

c. **Operational Communication:** Addresses regular correspondence regarding the operational facets of maritime operations, including port operations, weather reports, and cargo handling.

2)**Classification Based on Technology**:

d. **Very High-Frequency (VHF) Communication:** Frequently utilized for close-quarters communication, such as ship-to-ship and ship-toshore.

e. **HF (High-Frequency) Communication:** Ideal for long-distance communication, especially for ships operating in open waters where VHF transmissions might be restricted. f. **Satellite communication:**

use of satellites to provide voice, data, and emergency communication on a global scale.

g. **The Automatic Identification System[AIS]:** improves situational awareness by automatically tracking vessels and exchanging navigational data.

3) **Communication Equipment Types:**

h. **Radio communication:** This type of communication uses satellite, HF, and VHF frequencies to send and receive data and voice. Using radio waves to locate and identify objects, i.**Radio Detection and Ranging[RADAR]:** aids in collision avoidance and navigation.

4) **Classification of Users:**

j. **Ship-to-Ship Communication:** When ships communicate while at sea.

k. **Ship-to-Shore Communication:** This refers to communication between ships and facilities located on land.

l. **Coastal communication**: It is the exchange of information between ships and coastal stations within a particular coastal area.

IV.STRUCTURE OF WIRELESS MARINE COMMUNICATION

1. **GMDSS (Global Maritime Distress and Safety System):** An internationally mandated system for safety and distress communication that combines different communication technologies

Fig 2:GMDSS Technology

2. **A computerized chart display and information system**

A digital navigation system shows electronic navigational charts (ENC) and other navigational data on a computer screen.

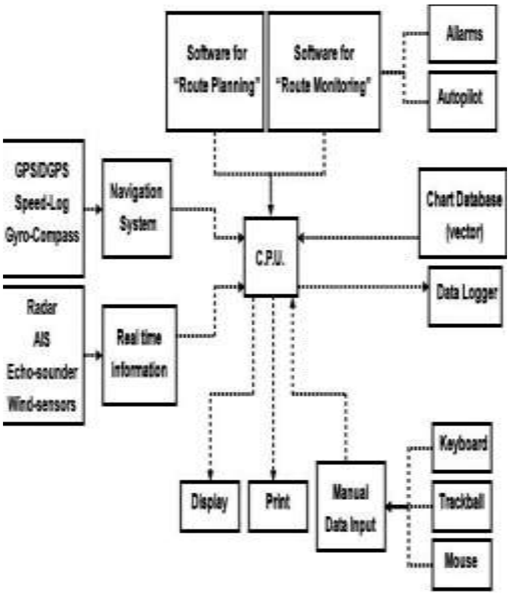

Fig 3: ECDIS Technology

3.EPIRB (Emergency Position Indicating Radio Beacon):

An evacuation indicator for boaters that, when triggered, notifies the global search for survivors (SAR) network, which is intended to promptly dispatch rescuers to your precise location

Fig 4: EPIRB Technology

3.ITU (International Telecommunication Union): ITU develops technical standards that guarantee networks and technologies work together seamlessly, distributes global radio spectrum and satellite orbits, and strives to increase underprivileged communities' access to ICTs globally.

Fig 5: ITU

4.SOLAS (Safety of Life at Sea) Convention: outlines global standards for nautical security, including GMDSS-based communication requirements.

Fig 6: Safety tool

V.ADVANTAGES & DISADVANTAGES

Advantages:

Flexibility and Mobility: On ships, boats, and other marine vessels, wireless communication enables increased mobility. This adaptability is essential for seamless connectivity even when in motion, enabling communication between various parts of a vessel or between multiple vessels.

Cost-Effectiveness: Because of the constantly changing marine environment, installing and maintaining wired communication infrastructure on ships can be costly and difficult. With wireless communication, there is no need for substantial infrastructure or cabling, making it a more affordable option.

Installation ease: In general, installing wireless communication systems is easier and faster than installing wired systems. In the maritime sector, where vessels may need to be deployed quickly or have little downtime for installation, this is especially crucial.

Diminished Maintenance: Wireless communication networks often require less maintenance than wired systems. Regular inspections and repairs are not as necessary because there are fewer physical components that are prone to wear and tear.

Scalability: Wireless communication systems are easily able to adjust to modifications in a vessel's size or configuration. Rewiring a ship to accommodate changes in its communication infrastructure is more complex than adding or removing wireless devices.

Disadvantages:

Signal degradation and interference: The maritime environment can be vulnerable to a number of different kinds of interference, including electromagnetic interference from nearby vessels, weather, and equipment on board. The reliability of wireless communication may be impacted by this interference, which can cause signal degradation. **Restricted Bandwidth:** The amount of radio frequency spectrum that is available for maritime communication is limited, and as more and more data-intensive applications are used, the need for bandwidth is rising. Reduced overall communication performance and slower data transfer rates can be caused by limited bandwidth.

Security Concerns: Compared to wired systems, wireless communication may be more vulnerable to cyberattacks and unwanted access. For marine vessels to avoid unwanted access, data breaches, or interference with vital systems, wireless network security is essential.

VI.APPLICATIONS

Onboard Entertainment and Connectivity: During crew members' downtime, wireless communication enables internet access and supports onboard entertainment systems. This can contribute to a more comfortable working environment and improve the crew's well-being during lengthy trips. **Weather and Environmental Monitoring:** Realtime weather and environmental data collection and transmission are made possible by wireless sensors and communication systems. Vessels can make more informed decisions with the use of this information, particularly when navigating through sensitive ecological areas or changing weather conditions.

Fleet Management and Logistics: fleet management are supported by wireless communication, giving operators the ability to monitor the where abouts, conditions.

VII.METHODOLOGIES

1.The ecological impact of nautical radio broadcasting diffusion:

It is a particular kind of maritime air-ground-sea communication network. Generally speaking, the terrestrial base station can provide direct service to a nearby user. Relay nodes, such as specialized ships or high altitude platforms (aircraft located 17–22 kilometers above the ground), are used when the distance increases.

2.**Instability:**

It is primarily caused by sea wave movement. It is caused by the moon's and the sun's gravitational attraction. Even if the user is stationary in a fixed spot. Wave-induced instability would cause periodic fluctuations in height. As a result, the influence on the onboard receivers can be separated into two parts: linear motions and rotational motions in the respective directions. The variations in received signal strength will be determined by these motions.

3.**Phenomenon of Evoporation Ducting:**

The air ducting effect has long been seen and studied, particularly for radar systems and military communications. The ducting effect is created by changes in refractivity at different heights of the atmosphere, which are induced by changes in atmospheric pressure, temperature, and humidity, among other things. There are three categories of atmospheric ducts based on changes in appearance heights and formulation conditions: surface ducts (including evaporation ducts), surface-based ducts, and elevated ducts. Figure depicts the trapping effect in the evaporation duct layer.

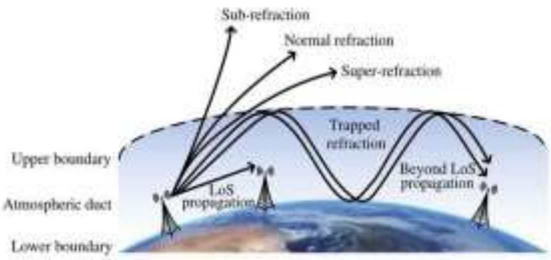

Fig 7: Trapping effect in evaporation ducting

4.**Sparsity**:

Two components of sparsity in a maritime channel are sparsity scattering and sparse user distribution. All that constitutes sparse scattering is the dispersion of electromagnetic waves that were transmitted by antennas from the atmosphere. For practically all channels, including air-to-sea, land-to-ship, and ship-toship, sparse scattering is applicable. Sparsity also plays a role in the number of multipath components (MPCs).

5.**Air to Sea surface channels:**

In marine communication, air-to-sea surface channels are essential because they allow information to be shared between maritime vessels on the ocean's surface and airborne platforms, like drones or aircraft.

6.PRINCIPLES OF THE AIR-TO-SEA CHANNEL:

1.FREE SPACE PATH LOSS:

The loss of signal strength as a function of distance in free space without any obstructions is known as free space path loss, or FSPL. The frequency of the signal and the distance between the transmitter and receiver both affect FSPL, which is the phenomenon that a signal experiences as it passes over water.

FreeSpace PathLoss(dB)=20log10 (d)+20log

10(f)+20log 10 (4π/c)

2.ROOT MEAN SQUARE DELAY SPREAD (RMS-DS): The square root of the second moment of the power delay profile is the RMS-DS, which is a measurement of a signal's time dispersion. It measures the different multipath components of a signal's time-spread**.**

RMS-DS= ∫ −∞∞**τ 2P(τ)dτ**

7.SEA – AIR SURFACE CHANNELS :

Sea surface channels play a crucial role in marine communication, enabling reliable and efficient data transmission over the vast expanse of the oceans. These channels exhibit unique characteristics due to the dynamic and reflective nature of the sea surface, presenting both challenges and opportunities for maritime communication systems.

KEY PARAMETERS OF THE SEA – AIR SURFACE CHANNELS :

1.LOS TRANSMISSION: LOS transmission is the most prominent communication mode utilized in short-range maritime tasks such as coastal traffic and near-sea fishing. The LOS path exists when the Tx-Rx distance is relatively short. Geometrically, the largest distance that can support LOS transmission can be calculated.

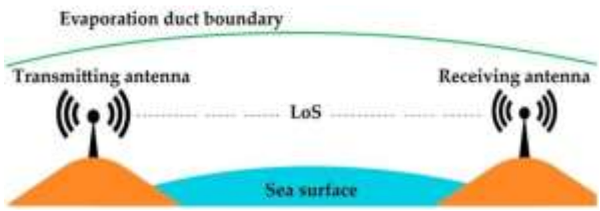

Fig 8: Los propagation pathway

8.RICIAN-K-FACTOR:

The Rician-K-Factor is defined as the ratio of signal power in dominant component over the scattered power.

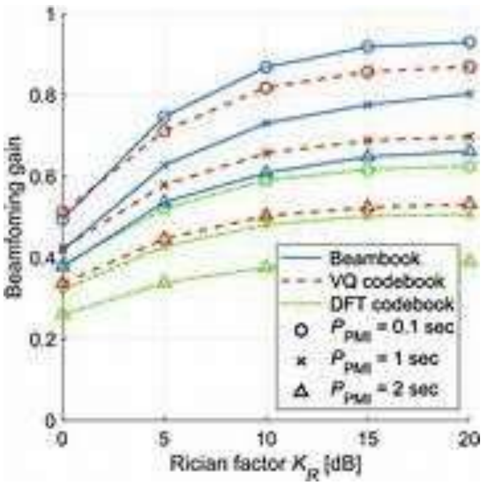

Fig 9: Rician k factor

9.SMALL-SCALE FADINGS:

The abrupt shifts in a radio signal's phase and amplitude over a brief period of time. The multipath propagation inside the duct layer must first be described. For this reason, estimating the potential arrived ray at a given point is best done using the ORT method. By summing up all the incoming rays at a given location, the ORT method is able to simulate the channel by approximating the electromagnetic propagation in different directions with distinguishable rays.

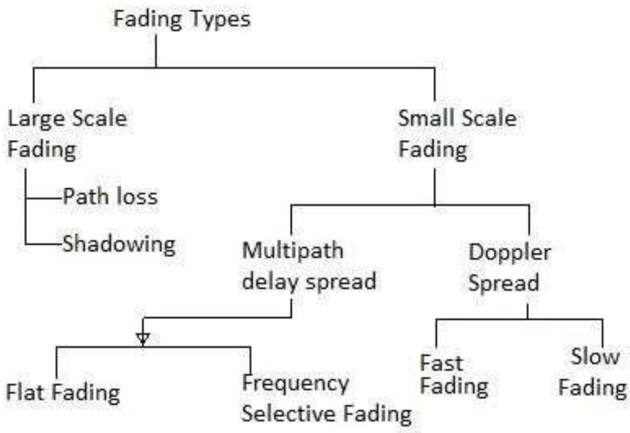

Fig 10: Small scale fadings

VII.RESULTS

An integrated wireless networking system for maritime communication, which includes a mobile ad hoc network, cellular mobile communication network. It reduces network deployment cost, calling charges, and support more terminal types, providing richer maritime services. It results for key parameters of the airto-sea channels, including loss Transmission, root mean square delay and the Rician K-factor. A greater variety of terminal types and offered superior marine services. Investigated using relay nodes in communication networks to extend reach.

More advanced models of maritime wireless channels are required, particularly for MIMO systems.

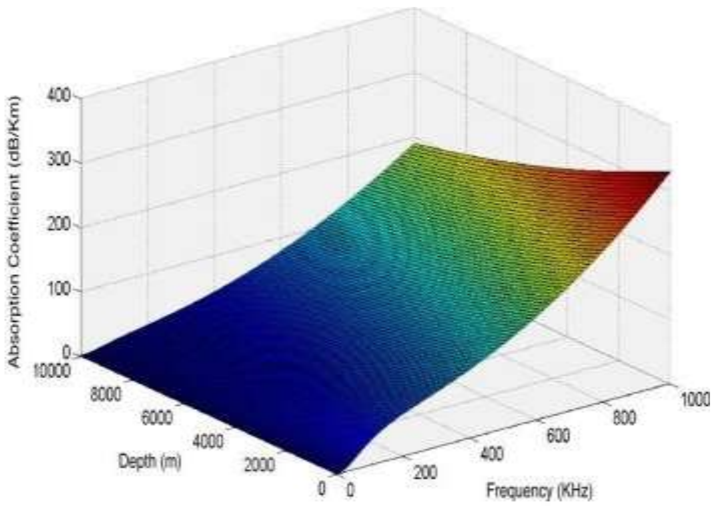

Fig 11: Resultant rician k factor

VIII.CONCLUSION

In this paper, we have performed a detailed review of the modeling approaches and measurement achievements for the maritime wireless channels, including both the air-to sea and near-sea-surface channel links. Existing results in the liter-ature have been summarized from the perspectives of the largescale path loss, small-scale fading, as well as other important channel parameters such as the Rician K factor and the delay spread. From the reviewed literature, we concluded that the two most distinctive features of the maritime wireless channels can be summarized as sparse and location-dependant. Specific to these unique features, we further dis- cuss their possible impacts and corresponding challenges that being raised to maritime communications design. Furthermore, we explore the construction of more advanced maritime wireless channel models as an appealing field for future research.

IX.REFERENCES

[1] A. Jennings, Modern Maritime Communications, document ITU-R WRS 16, ITU World

[2] Radiocommun. Seminar, Geneva, Switzerland, Dec. 2016. [Online] Available:

[3] D. Kidston and T. Kunz, ‘‘Challenges and opportunities in managing maritime networks,’’ IEEE Commun. Mag., vol. 46, no. 10, pp. 162–168, Oct. 2008.

[4] W. Du, M. Zhengxin, Y. Bai, C. Shen, B. Chen, and Y. Zhou, ‘‘Integrated wireless networking architecture for maritime communications,’’ in Proc. 11th ACIS Int. Conf. Softw. Eng., Artif. Intell., Netw. Parallel/Distrib. Comput., London, U.K., Jun. 2010, pp. 134–138.

[5] M.-T. Zhou and H. Harada, ‘‘Cognitive maritime wireless mesh/ad hoc networks,’’ J. Netw. Comput. Appl., vol. 35, no. 2, pp. 518–526, Mar. 2012

[6] Maritime Broadband Wireless Mech Networks, document ITU-R M. 2202, Nov. 2010

[7] M. J. Lopes, F. Teixeira, J. B. Mamede, and R. Campos, ‘‘Wi-Fi broadband maritime communications using 5.8 GHz band,’’ in Proc.Underwater Commun. Netw. (UComms), Sestri Levante, Italy, Sep. 2014, pp. 1–5.

[8] L.Santos, ‘‘Wi-Fi maritime communications using TV white spaces,’’ M.S. thesis, Fac. Eng., Univ. Porto, Porto, Portugal, Jul. 2013

[9] R. G. Garroppo, S. Giordano, and D. Iacono, ‘‘Experimental and simulation study of a WiMAX system in the sea port scenario,’’ in Proc. IEEE Int. Conf. Commun. (ICC), Dresden, Germany, Jun. 2009,pp1–5.

[10] R. G. Garroppo, S. Giordano, D. Iacono, A. Cignoni, and M. Falzarano, ‘‘WiMAX testbed for interconnection of mobile navy units in operational scenarios,’’ in Proc. IEEE Mil. Commun. Conf. (MILCOM), San Diego, CA, USA, Nov. 2008, pp. 1–7.