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Research Article

Opportunities Provided by Developments in Marine Data Communication Systems in Determining the Coastal Safe Transportation Strategy

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Abstract: Today, developments in communication systems offer great opportunities for effective control and inspection of coasts. Especially developments in wireless communication systems offer many new opportunities for countries to effectively manage their coasts. While these developments in communication systems lead to problems such as marine pollution in the surrounding seas of countries, safety of life and property at sea, irregular migration, effective use of maritime transportation, maximum utilization of seafood, they also offer very important opportunities in many areas. As it is known, uncontrolled migration, which has become a big problem even for landlocked countries in recent years, is largely carried out by sea and therefore the security of coasts has become an international issue. In addition, in our world where natural resources are decreasing, keeping the seas clean and making maximum use of the opportunities offered by the seas have become one of the most important areas of interest for countries. Developments in technology in recent years offer very important opportunities to countries and their administrations in all these issues. Today, new opportunities provided in wireless communication and the use of data communication in these systems also make it possible to automatically collect and evaluate many data. In this regard, the shifting of channels used in marine VHF systems to data communication in recent years has become an important communication infrastructure for the collection of data related to the seas. In addition, with the arrangements made in the GMDSS legislation, Iridium satellite systems have become one of the mandatory systems that can be used as an alternative on ships. Again, in recent years, although not mandatory, the intensive use of satellite systems such as Starlink on ships has facilitated the instant data reception from ships and seas. In this way, it has become possible for the relevant authorities of the countries to obtain detailed information about the surrounding seas and to manage their coasts more easily.

Keywords: Maritime Data Communication, Safe Management of Coasts, Maritime Management, Automatic Identification Systems, Marine Communication Systems, GMDSS Rules.

Deniz Data Haberleşme Sistemlerindeki Gelişmelerin Kıyıların Güvenli Ulaşım Stratejisinin Belirlenmesinde Sağladığı Fırsatlar

Özet: Günümüzde haberleşme sistemlerindeki gelişmeler kıyıların etkin bir şekilde kontrol ve denetimi için büyük fırsatlar sunmaktadır. Özellikle kablosuz haberleşme sistemlerindeki gelişmeler ülkelere kıyılarını etkin bir şekilde yönetmeleri için birçok yeni fırsat sunmaktadır. Haberleşme sistemlerindeki bu gelişmeler ülkelerin çevre denizlerinde deniz kirliliği, denizde can ve mal güvenliği, düzensiz göç, deniz taşımacılığının etkin kullanımı, deniz ürünlerinden azami ölçüde faydalanma gibi sorunlara yol açarken birçok alanda da çok önemli fırsatlar sunmaktadır. Bilindiği üzere son yıllarda denize kıyısı olmayan ülkeler için bile büyük bir sorun haline gelen kontrolsüz göç büyük ölçüde deniz yoluyla gerçekleştirilmekte ve bu nedenle kıyıların güvenliği uluslararası bir konu haline gelmiştir. Ayrıca doğal kaynakların azaldığı dünyamızda denizlerin temiz tutulması ve denizlerin sunduğu imkânlardan azami ölçüde yararlanılması ülkelerin en önemli ilgi alanlarından biri haline gelmiştir. Son yıllarda teknolojideki gelişmeler tüm bu konularda ülkelere ve yönetimlerine çok önemli fırsatlar sunmaktadır. Günümüzde kablosuz haberleşmede sağlanan yeni imkânlar ve bu sistemlerde data haberleşmesinin

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kullanılması, birçok verinin otomatik olarak toplanmasını ve değerlendirilmesini de mümkün kılmaktadır. Bu bağlamda son yıllarda deniz VHF sistemlerinde kullanılan kanalların data haberleşmesine kaydırılması, denizlerle ilgili verilerin toplanması için önemli bir haberleşme altyapısı haline gelmiştir. Ayrıca GMDSS mevzuatında yapılan düzenlemelerle Iridium uydu sistemleri gemilerde alternatif olarak kullanılabilecek zorunlu sistemlerden biri haline gelmiştir. Yine son yıllarda zorunlu olmasa da Starlink gibi uydu sistemlerinin gemilerde yoğun olarak kullanılması gemilerden ve denizlerden anında veri alınmasını kolaylaştırmıştır. Bu sayede ülkelerin ilgili otoritelerinin çevre denizler hakkında detaylı bilgi edinmeleri ve kıyılarını daha kolay yönetebilmeleri mümkün hale gelmiştir.

Anahtar Kelimeler: Deniz Data Haberleşmesi, Kıyıların Güvenli Yönetimi, Deniz Yönetimi, Otomatik Tanımlama Sistemleri, Deniz Haberleşme Sistemleri, GMDSS Kuralları.

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1. Introduction

Transport constitutes the main function in the realization of global trade; through this function it connects countries through global trade (WMU, 2019; Saka and Çetin, 2020). Maritime transportation, which mediates the transportation of more than 80% of world goods trade in volume, is the backbone of globalized trade among transportation types (UNCTAD, 2019; Saka and Çetin, 2020). The most important factor in maritime transportation being the most preferred transportation mode is that it is cheaper than other transportation modes.

Especially in recent years, it has become possible to deliver very large amounts of cargo to their recipients in one go with increasingly larger ships. This situation causes unit transportation costs in maritime to be much cheaper than other transportation modes. According to the evaluations, the unit transportation cost of maritime transportation is 3 times cheaper than railway, 7 times cheaper than land, and 21 times cheaper than air (Yılmaz, 1990). In addition, it is possible to say that all long-distance and intercontinental cargo transportation, where the speed factor is not very important, is carried out by sea. For this reason, maritime transportation is a transportation mode with no alternative at many transportation points (Kögmen, 2014).

Apart from this, when the cargo volume carried is taken into consideration, maritime transportation is considered the safest transportation mode after air transportation in terms of safety and accident risk. For this reason, a large part of the transportation of large-volume goods in world trade is carried out by sea (Fulser, 2015). An analysis of data stored at the "United Nations Trade and Development (UNCTAD)" Data Center shows that global maritime transport grew at a compound annual growth rate of 2,9% between 1970 and 2021. Maritime trade is mainly affected by developments in the world economy, including GDP and global trade. Up to 2028, total seaborne trade is expected to grow at an annual average rate of 2.4%, and the containerized trade to grow that of 2.7% in the same period (UNCTAD, 2024). Container transportation, which has shown the fastest growth among transport modes, has provided significant flexibility in the logistics system (Hesse and Rodrigue, 2004). The increase in global maritime trade has also necessitated improvements in the ports and terminals handling these merchandise goods (Saka and Çetin, 2019).

The gradual increase in maritime transportation, both in volume and in the number of operating boats and vessels, is of great importance, especially for the effective management of the coasts.

2. Study Area

2.1. Increase in Data Amount

Today, the most important developments in technology are mostly seen in the IT sector. Digital Twin, Metaverse, Blockchain, Cryptocurrencies, Big Data, Data Analytics, Industry 4.0, Internet of Things (IoT), Machine to Machine (M2M), Artificial Intelligent etc. are all technologies that have emerged in the IT sector in the last 10/15 years. The impact of these developments in the IT sector has not been limited to this sector only but has also affected all sectors related to the IT sector to different extents. This interaction is still continuing at an increasing pace. Today, one of the most important areas of interest in the IT sector is data communication and the analysis and interpretation of the collected data.

2.2. Systems Used in Data Collection

Data is as valuable as the oil of our age and its value is constantly increasing. Today, there are many types of data and different tools are used to collect and process them. Each of these tools, also called sensors, is used in different data sources. The data produced by these sources must be converted to the binary number system so that computer systems can understand it.

With the developing technology, the size of the sensors is decreasing, and it is possible to collect the data produced in this way more easily.

Wired and wireless systems are used for data communication in the IT sector. If a large amount of data is to be transferred with wired systems, the most suitable infrastructure for this is Fiber Optic cables. However, today, wireless access infrastructures are generally preferred for transferring data related to different systems.

These systems are mobile communication systems defined as 2G, 3G and 4G. There can also be communication methods such as WiFi, Bluetooth, NFC, etc. There can also be local and local access systems. As a result of the developing technology in recent years, significant increases have been achieved in both the data capacity of the systems used in this communication and the speed of the transmitted data.

2.3. Wireless Systems Used in Data Communication

Along with the developments in wireless technologies, wireless communication network within the maritime sector emerges as one of the significant information transmission systems (Yang et al., 2015). While wired transmission systems are used to transmit data from the places where it is produced to the systems where it is processed and evaluated, wireless systems have replaced this communication in recent years.

Although there are many wireless systems, the most widely used among them are mobile communication systems defined as generation. The most widely used and highest data communication speed among these is the fourth generation (4G) systems. Many countries still use the Advanced LTE (LTE Advance) system, which is the advanced version of this generation and defined as 4.5G in Türkiye. The graph in Figure-1 shows the development of mobile communication standards and new wireless technologies in detail over the years.

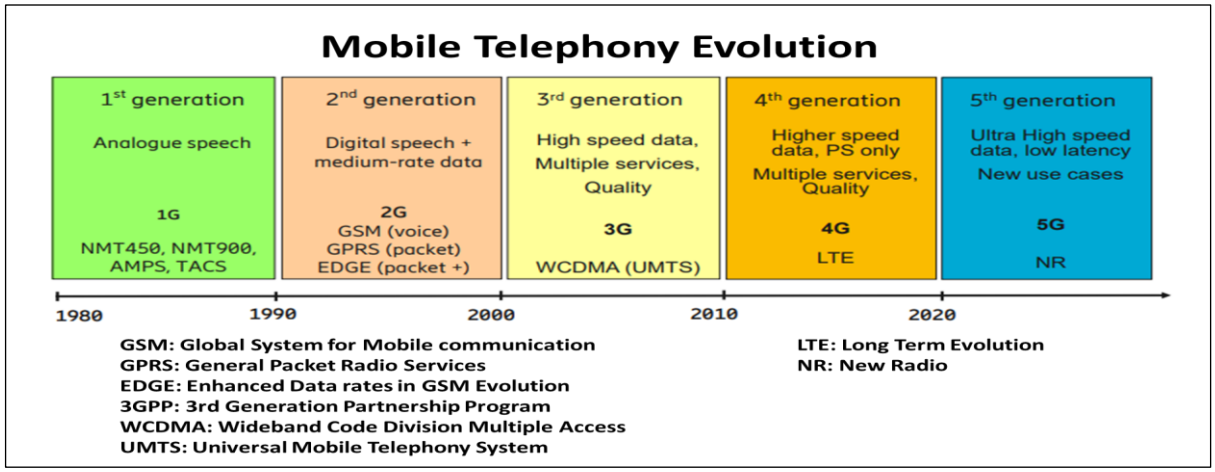

Figure 1: Current Mobile Communication Standards and the Evolution of New Wireless Technologies (Čačković, 2019).

Since the data rate has reached very high levels in the LTE Advance system, the delay in transmitting data generated through sensors and objects to the central processing units has been reduced to milliseconds (Acarer, 2021). Therefore, it can be said that a great development has been achieved in data communication in the IT sector as a result of the start of the use of 4G systems. This causes 4G to be the most preferred system in data communication.

In recent years, fifth generation systems defined as 5G have also started to be used in mobile data communication. However, since the targeted speed and data capacity with 5G are much higher than 4G, it will take a few more years to spread the fiber optic infrastructure required in this system. In addition, since private networks were initially preferred in the establishment of 5G, it is not yet possible for this system to become a national system and be used everywhere in data communication.

2.4. Big Data and Data Analytics

In recent years, the most important differentiation in the IT sector is seen in the increase in the data produced. Because the amount of data produced is increasing every day. As can be seen from the graph in Figure-2, the amount of each data increases two-fold every two years. It is estimated that the global data traffic, which was 20 ZByte in 2015, will reach 125 ZByte by the end of 2025.

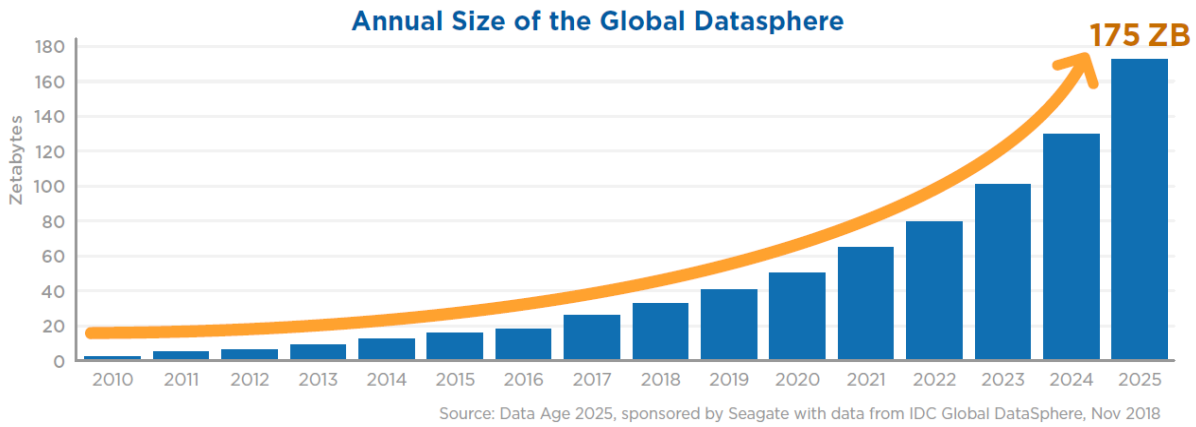

Figure 2. Annual Size of Global Data (Reinsel et al., 2013).

The most important reason for this is that the number of sources that produce data, the data produced, and the sensors that perceive the data are increasing day by day. Since data transmission environments have developed rapidly in recent years, it has become easier to transmit the produced data for evaluation.

Although it is possible to compress large data into smaller areas with some compression applications (zip), very large capacity storage equipment (disks, servers, etc.) is needed due to the increasing amount of data.

Data analysis, also defined as Data Analytics, is the evaluation, interpretation, processing, and commercialization of collected large data. Data collection and its interpretation have become a very important area of informatics in recent years. Because a data stack that cannot be interpreted and therefore cannot be commercialized has no scientific meaning and is considered only a data stack.

In today's world where the collected data is becoming increasingly valuable and is considered the oil of the 21st century, the importance of artificial intelligence is also increasing. Artificial Intelligence (AI) is one of the most popular topics in the IT sector in recent years. "Artificial intelligence" is the engineering or science of making smart machines, especially smart computer programs (Sucu, 2019). In a process where big data is processed and commercialization activities are increasing, the importance of artificial intelligence is increasing. Because artificial intelligence plays a major role in data analysis and then in the meaning function. In addition, making quick decisions according to the collected data and determining the most accurate action plan is as important as the collected data itself. Therefore, evaluating the collected data and finding the most appropriate solution for the targeted purpose is only possible by using advanced software and hardware systems.

Again, one of the important areas that has attracted attention in the IT sector in recent years is machine learning. Machine learning should be considered together with artificial intelligence and the fastest evaluation of data should be considered as one of the elements to be taken into consideration.

3. Problem Definition

3.1. Opportunities Provided by Developments in Marine Data Communication for Effective Coastal Management

Effective use of the seas is an extremely important issue for coastal countries. Because countries that make maximum use of the seas provide great advantages both economically and strategically. Today, 85% of the cargo carried in world trade and 97% of energy transportation are carried out by sea.

In addition, approximately 75% of the world's population lives in coastal areas and close to the coast (Usluer, 2015). Therefore, effective monitoring of the seas and coasts is an extremely important issue for coastal countries.

3.2. Monitoring of Marine Pollution

The problem of marine pollution is the area of interest of many international organizations. For this purpose, different conferences and meetings are organized every year on this subject and the attention of all relevant authorities is drawn. Again, this issue is one of the basic functions of the international maritime organization, special working groups have been established within the IMO and serious responsibilities have been brought to the coastal countries regarding the cleanliness of the surrounding seas by international agreement.

For this reason, countries aim to instantly observe the pollution in the surrounding seas by establishing different observation systems in order to fulfill these responsibilities. Because if the sea pollution is constantly increasing, it becomes very difficult and costly to rehabilitate the seas after a certain point (Muslu, 2018).

Today, quite different sensors and detectors are used in the installation of systems related to monitoring sea pollution. Data on sea pollution is collected through these sensors and these are sent to data processing centers via different wireless systems. Although different infrastructures are used in data communication, the most commonly used systems in this regard are mobile communication systems such as 3G and 4G. In addition, automatic ship identification (AIS) systems, which have increased in use in recent years, are also used by coastal administrations in the use of data related to the seas.

In recent years, different satellite systems have also started to be used in the collection of many data related to the seas. The most important of these systems are Inmarsat F77, Iridium, Starlink, etc. systems with data communication capabilities.

3.3. Communication for the Safety of Life and Property at Sea

In case of a ship in distress, informing the Search and Rescue units of the incident and initiating assistance activities as soon as possible is one of the most important elements for the success of the rescue/aid process (Acarer, 2018). Many of the most important regulations in maritime transportation have been made regarding the safety of life and property at sea, and the regulations on this subject are still ongoing. The first regulations on the safety of life and property were collected under the title of SOLAS (Safety of Life at Sea). The regulations made in 1974 on this subject were collected under the title of SOLAS-74 and turned into a collection of maritime communication rules (Ece, 2018).

The issues related to the safety of life and property at sea include not only the safety of seafarers, but also the safe transportation of the ship and the cargo on the ship. For this purpose, coastal countries are establishing different radio systems. Countries aim to automatically or manually receive wireless distress/safety broadcasts from ships at different distances from the shore through these systems and then initiate rescue/assistance activities.

Currently, terrestrial systems such as VHF, MF and HF devices and satellite systems such as Cospas Sarsat, EPIRB and Inmarsat devices are used in distress/safety broadcasts made by ships.

The International Maritime Organization (IMO) has been determining the minimum standards required for personnel and ships to prevent maritime accidents since its establishment (Kaptan and Uğurlu, 2022). IMO's obligation is to receive these broadcasts from coastal countries regarding the safety of life/property without any problems and to initiate the rescue/assistance function without delay when necessary. Therefore, countries with coasts are obliged to establish systems that will automatically or manually receive distress/safety broadcasts from ships and to actively operate these systems.

3.4. Maximum Utilization of Seafood

The importance of seafood is increasing day by day as the world's resources are rapidly decreasing. In many countries, the income obtained from the export of seafood has become one of the most important export items of these countries. Since the price of these products increases day by day, the share of income obtained from the sea in total exports will increase even more for the countries.

Products obtained from the sea should not be defined only as fish etc. Since fishing is not only done in the coastal areas of a country, the share of open sea fishing in total fish production is also increasing. Open sea fishing is carried out even in many countries without a coastline. Fishing boats of these

countries generally stay in neighbouring countries with the closest coast to the sea and benefit from open sea fishing.

As a result of developing technology today, problems such as spoilage, delay etc. in sending fish caught by open sea fishing to distant countries are minimized. This situation makes open sea fishing even more attractive for all countries. Today, this issue has become a very important source of income for many countries.

Meanwhile, as a result of developing technology in recent years, both the production capacities of seafood produced in sea farms established in inland seas, lakes, dams and rivers such as the Marmara Sea have increased, and unit costs have decreased significantly. For this reason, seafood obtained from the sea should not be considered only as fish etc. products but should be evaluated as sources of income obtained from all fishing products in a broader perspective.

3.5. Irregular Migration Movements

One of the most important international problems today is irregular migration movements. Even if the countries of origin of migration are far away, all countries are affected by this process at different rates. This effect is generally greater in developed countries, and all countries on the route from the countries of migration to developed countries are also affected by this process at different rates. The most obvious examples of this are clearly seen in the migration movements from neighbouring countries to Europe in recent years.

Many dramatic events have occurred in the process of irregular migration movements detected to date. For this reason, serious arrangements have been made in many international organizations in recent years to find a solution to this issue that causes the problem in question.

The first thing that is requested from all countries in this regard is to take the necessary measures regarding country borders. For this reason, it is of great importance to establish effective surveillance and control mechanisms at the border. The weakest link for countries in this regard is the seas. Because although the land borders of countries can be controlled more effectively with the possibilities of developing technology today, the same success cannot be achieved in preventing irregular migration by sea. For this reason, it is necessary to equip the coasts with different systems and control and monitoring systems in preventing irregular migration movements. For this purpose, it is necessary to establish the required systems on the coastlines and to make physical interventions by evaluating these systems instantly.

4. Materials and Methods

In this study, firstly, the systems used in maritime communication will be examined in the Research section. After giving brief information about maritime communication systems, the systems and the devices within the scope of these systems will be examined in detail. In this way, the features of the devices within the scope of communication systems and the purposes for which they are used, or new areas of use will be specified.

In the Discussion section, it will be discussed whether the devices and sensors analysed in the Research section can be used to ensure effective and continuous control of the seas and coasts, in which areas they can be used, and in which areas new technologies and sensors offer opportunities to users.

The study and the results obtained will be summarised in the Conclusion section.

5. Research

5.1. Systems Used in Marine Communication

Two different systems are currently used in marine communication systems between ship/ship and ship/land. These are Satellite and Terrestrial marine communication systems. The devices used in these systems, which are different from each other in terms of communication infrastructure, are also completely different in terms of technology. While satellites are used as relays in communication via satellite systems, communication in the terrestrial system is carried out either on the basis of the antennas seeing each other directly or the reflection of signals from the ionosphere.

In maritime satellite systems, communication between ship/ship and ship/land is done via satellites. In the past, only Inmarsat and Cospas Sarsat satellites were used in this system, but today Iridium, Starlink etc. satellite systems have also started to be used.

In terrestrial systems, communication between ship/ship and ship/land is done based on the reflection of electromagnetic waves from the ionosphere or the direct vision of the antennas of the radio devices. In terrestrial maritime communication systems, short, medium and long-range wireless systems are used.

5.2. Marine Satellite Communication Systems

In satellite systems, the frequencies used in ship/ship and ship/land communication are reflected via satellite. In other words, satellites act as relays in communication between two satellite terminals. Until a few years ago, two different satellite systems had been used in marine communication. These are the Inmarsat and Cospas Sarsat satellite systems. Figure-3 shows the locations and coverage areas of the Inmarsat system satellites.

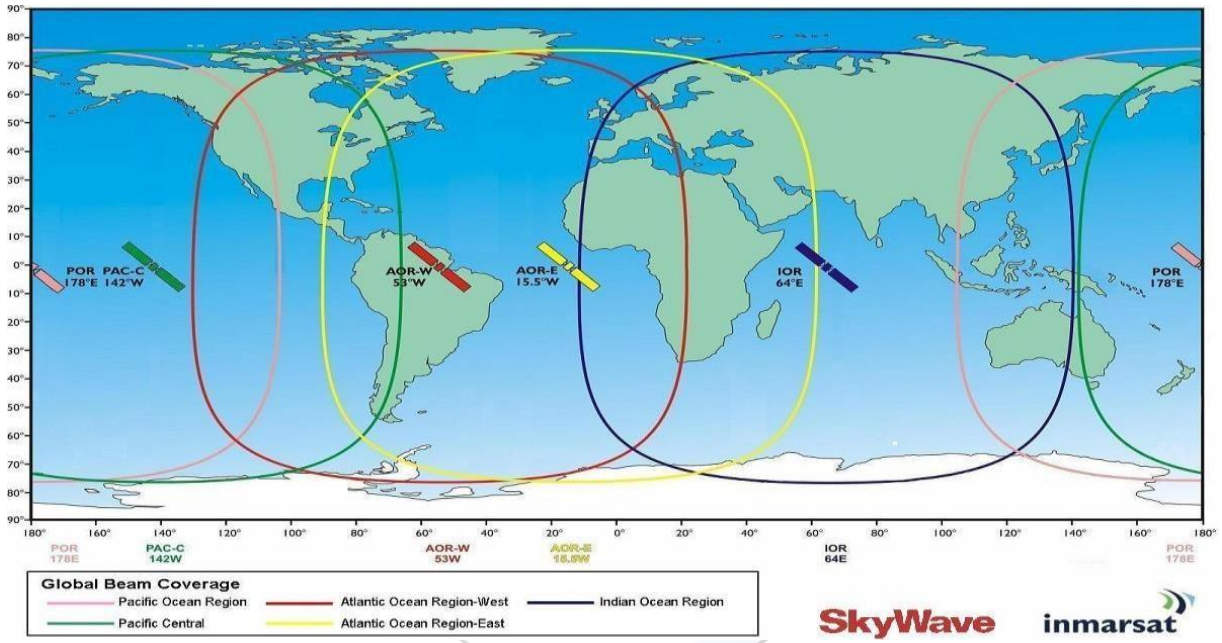

Figure 3. Inmarsat Satellite System (Ekinalan et al., 2020).

The Cospas Sarsat system is operated by an organization formed with the participation of different countries. Official and private commercial communication is not carried out through this system. The Cospas Sarsat system is used only for Distress communication; Urgency and Safety content communication cannot be carried out through this system.

In recent years, Iridium devices have also started to be used in marine communication according to the GMDSS legislation. Since this system has a global structure, it is successfully overlapping in all sea areas around the world. As a result of the Iridium system being accepted as a system that can be used especially in long-distance ships in accordance with the GMDSS legislation, its use on ships has started to spread rapidly.

Another satellite system that has been rapidly increasing in use on ships for several years is Starlink. Although this system is not currently defined in the GMDSS legislation, it is rapidly becoming widespread on ships due to its technical features. The most important common feature of new satellite systems is that they are "Broadband". This feature provides significant opportunities for the Administrations in the effective control of the coasts of these systems.

5.3. Terrestrial Maritime Communication Systems

Today, the most commonly used devices for ship/ship and ship-land communication are terrestrial communication systems. These systems are not only used for official and private communication of ships but are also used extensively between surrounding ships and units on land during the course of ships. The main systems used in terrestrial marine communication are;

- VHF (Very High Frequency - Very High Frequency),

- MF (Medium Frequency - Medium Frequency),

- HF (High Frequency - High Frequency) and

- Navtex (Navigational Telex - Written Navigational Warnings).

The frequencies, communication distances and communication types (telephone, telex, data, etc.) used in these systems are quite different. For this reason, the systems in question are used for different purposes.

The most commonly used device in terrestrial system marine communication is VHF. In addition, since VHF devices are very easy to use, they are the most preferred equipment by sailors of all training levels.

In accordance with GMDSS legislation, DSC (Digital Selective Calling) feature has been added to these devices and automatic communication capability has been gained. Both routine and distress/safety communication can be made automatically via the DSC system (Acarer, 2016).

DSC devices are technically a data-based technology. These devices have a feature that allows calls to be received and sent automatically even if there is no person present. For this reason, VHF devices with DSC feature have been made mandatory for ships by IMO in GMDSS legislation.

Both the frequencies and powers of the devices used in the VHF system are standard. These systems operate on the principle that the antennas of the VHF devices can see each other. In this system, the communication distance of the two VHF systems varies according to the height of the antennas of these systems above the sea. The factor that limits this distance is the optical line of sight. When the optical line of sight is accepted as 25 NM (nautical miles), it is possible to define the communication distance between two ships as a maximum of 25 NM (Demir, 2009).

On the other hand, within the communication between the ship and the coast radio station (CRS), if the coast radio station is located on a hill or mountain above sea level, as in Türkiye, the optical visibility will also increase according to this height. This distance is determined by the formula below.

$$l = 2.25 \text{ x } [\sqrt{h1} + \sqrt{h2}] \text{ NM}$$

In this formula;

l: communication distance,

h1 and h2: the heights of the transmitter and receiver antennas (on 2 different ships) in meters above sea level.

According to the formula above, if the communication distance between a ship with a VHF antenna at 36 m above sea level and a Coastal Radio Station (CRS) at 1600 m is calculated;

$$l = 2.25 \text{ x } [\sqrt{h1} + \sqrt{h2}] \text{ NM}$$

$$l = 2.25 \text{ x } [\sqrt{36} + \sqrt{1600}] = 2.25 \text{ x } [6 + 40] = 2.25 \text{ x } 46 \text{ NM}$$

$$l = 103.5 \text{ NM}$$

According to the figure below; The communication distance between a marine vessel with a VHF antenna at 9 m above sea level and a VHF system on a ship at 62 m above sea level is;

$$l = 2.25 \text{ x } [\sqrt{h1} + \sqrt{h2}] \text{ NM}$$

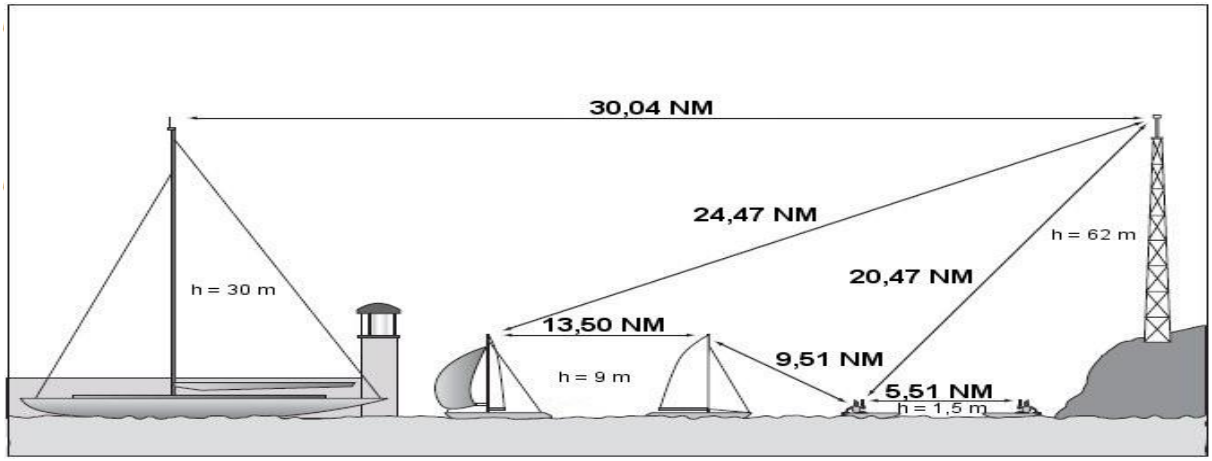

Figure 4: Communication distance between a marine vessel with a VHF antenna at sea (Ekinalan et al., 2020).

According to the figure above, the communication distance of the VHF systems of two marine vessels whose antenna heights are "9 m" above sea level is;

$$l = 2.25 \text{ x } [\sqrt{h1} + \sqrt{h2}] \text{ NM}$$

$$l = 2.25 \text{ x } [\sqrt{9} + \sqrt{9}] = 2.25 \text{ x } [3 + 3] = 2.25 \text{ x } 6 \text{ NM}$$

$$l = 13.5 \text{ NM}$$

The other important equipment of the terrestrial system is MF (Medium Frequency). Medium Wave marine radio devices are systems used at a distance of approximately 300-400 NM from the shore. MF systems, which were previously used intensively in radiotelephone and radiotelegraph communication, are now preferred mostly for distress/safety communication purposes due to GMDSS legislation. In MF systems, the communication type defined as Ground Wave is used.

HF (High Frequency) marine communication systems, also defined as long-distance systems, are used in ship/ship and ship/land communication with ships located in different parts of the world according to the preferred frequency band. In this system, communication is carried out according to the reflection of electromagnetic waves from the ionosphere (sky wave). Since the reflection process is a natural structure, there is no possibility of the said reflector (ionosphere) being disrupted or destroyed. In this respect, it is possible to define the HF system as a highly reliable form of communication from a strategic perspective. The frequency bands used in the HF system and the layers of the ionosphere where they reflect are shown in Figure-5.

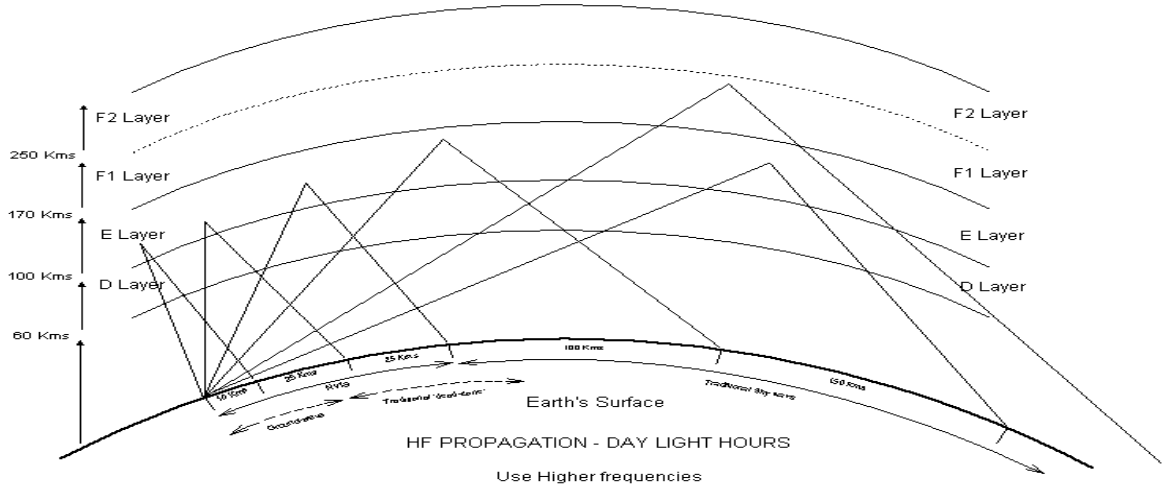

Figure 5: Reflection of HF Waves from Different Layers of the Ionosphere (Yılmaz and Acarer, 2014).

One of the most important systems used in maritime communication is Navtex. This system, which provides written navigation warnings, is of great importance for the safe navigation of ships. In the Navtex system, MF band frequencies are used, and one-way broadcasts are executed from coastal radio stations to ships.

5.4. Systems for Maritime Data Communication

A revolutionary decision was made at the WRC -19 (World Radio Conference - 19) meeting (held in 2019), one of the regularly held meetings of the IMO (International Maritime Organization). According to this decision, all duplex channels (channels where the receiver and transmitter frequencies are separate) in the VHF system were allocated to data communication within the specified time (Reinsel et al., 2018).

In addition, the channel range was expanded by combining the channels that were close to each other, thus providing the necessary bandwidth for fast data communication over VHF devices.

Data transmission is very important in communication systems. Because today, as a result of the evaluation and interpretation of data obtained from different systems by central processing units, it has become easy to track a lot of information. For this reason, the use of systems that provide data communication in the IT sector has become increasingly widespread in recent years.

This development has provided very important inspection and evaluation opportunities for different organizations regarding coastal inspections regarding the systems they are responsible for.

In order to benefit from these developments in the IT sector to the maximum extent in maritime communication, arrangements were made primarily in the channel structures of VHF systems for data purposes. For this purpose, as a result of the meeting mentioned above, it was decided that all duplex channels used in the VHF system would be used for data communication (Acarer, 2024). With this arrangement, coastal authorities were provided with the opportunity to effectively inspect ships, surrounding seas and coasts. In this way, the necessary technical infrastructure was provided for the authorities in question to instantly monitor, evaluate and make effective decisions on information obtained from data production sources.

Today, local-based systems such as WiFi (Wireless Fidelity) are also used in data transmission. These systems, also defined as Wireless Local Area Networks (WLAN), are generally used for wireless internet in small areas. The speed of these systems is much lower than 4G and 5G networks. For this reason, the use of mobile communication networks, also defined as generations in data transmission, has increased significantly in recent years.

In recent years, one of the systems used especially in data collection at sea is Automatic Identification Systems (AIS). It is mandatory to install this system on ships for navigation safety purposes under the provisions determined by IMO, and it is easily possible to automatically collect data about ships in the vicinity of the coastal areas.

Today, it has become possible to obtain sufficient data for the ships' own management and control as a result of the evaluation of both the navigation information to be received from the ships around via AIS devices and the navigational assistance information to be sent via Virtual AIS on the ship's computer (Acarer, 2023).

In recent years, AIS systems have been in use intensively in Türkiye and some coastal countries to transmit information such as current strength and direction, wind direction and strength, detection of sea pollution, etc., received from equipment placed on buoys to the shore.

Since AIS systems operate in the VHF band (AIS1 channel: 161.975 MHz, AIS2 channel 162.025 MHz) and these systems are generally mounted on high hills, the sea area controlled from the shore is quite large (Acarer, 2016). The calculation of this distance is explained in detail in “article 5.3” above.

5. Discussion

Effective control and surveillance of coasts is extremely important for the national and international interests of countries. Especially, the pollution of the surrounding seas and the safety of life/property of the ships and passengers in these seas are among the most important issues concerning the coastal

countries. In addition, the increasing importance of marine products is very important for the economies of these countries. On the other hand, preventing irregular migration movements is becoming increasingly important as a very serious problem in the international relations of countries. Marine communication systems used on ships are wireless technologies. For this reason, the use of wireless systems is a technical necessity in transmitting the data collected through systems to be established in the seas and on the seashores to the evaluation center without delay and loss. As a result, it is very important to choose the most effective and accurate systems that will provide wireless communication between the most important reflections of the technological developments in recent years are seen in the information and communication sector. Today, mobile communication systems, also defined as generations, have provided many new opportunities in the communication sector (Acarer, 2024).

In particular, the increase in the rate of data communication in mobile communication systems allows data to be transmitted without loss or delay from different sources. The increase in the amount and speed of data transmitted in each new generation is another important issue in this regard. Although 5G is seen as the most advanced system in this regard, this system has not yet become widespread locally and an international network has not been established. Therefore, the most suitable mobile communication system that can be used for these studies is the fourth-generation system (Acarer, 2023).

In recent years, it has become possible to use some new marine communication systems that have started to be used in many countries, including Turkey, in such coastal inspections. Among these systems, VHF, the most commonly used terrestrial marine communication system, has technically become possible to use for this purpose. Because the regulations made within the IMO a few years ago paved the way for data communication over this system. With these regulations, all duplex VHF channels have been allocated to marine data communication.

It is technically possible to communicate via Inmarsat, another type of maritime communication satellite system. However, the installation and operating costs of these systems are much higher than terrestrial systems. This is the most important negative factor that prevents this system from being preferred for this purpose. For this reason, it is useful to carefully evaluate the costs of using the Inmarsat system in coastal control and surveillance activities.

Again, in line with the decisions taken within IMO, Iridium satellite system has been accepted as a system that can be used as an alternative on ships. It is technically possible to use this system for data communication in coastal control. Although this system is cheaper than Inmarsat, it is much more expensive than AIS and VHF systems.

One of the wireless communication systems that has developed and become widespread rapidly in recent years is AIS. The main purpose of these devices is electronic navigational aid systems, and they must be installed on ships according to IMO legislation. Due to its technical capability, this system has been used in many countries in recent years for the transmission of large amounts of marine data to land.

The free transmission of data in the AIS system is also an important factor in the widespread use of this system. For this reason, this system should be considered as a serious communication tool in the data communication of the systems to be established by coastal administrations.

In addition, since AIS devices operate within the VHF band (156-174 MHz), the coverage area of this band and therefore AIS devices is much larger than mobile communication systems such as 4G and 5G. Therefore, this issue should also be considered in the evaluations to be made.

6. Conclusion

Making the wrong choices for the delivery of the data produced in many surveillance and control systems to the evaluation centers on land prevents the successful operation of these systems. Because when the communication systems are chosen incorrectly, no matter how accurate the sensors for different purposes produce data, great difficulties are experienced in delivering them to the centers on land. Even if the selected systems technically fulfill their functions, the installation and operating costs make it impossible for these systems to operate for a long time. This issue is considered an indispensable element for the successful operation of the system to be established.

In this study, the issue of effective control and management of coasts is discussed. In addition to the sensors to be installed for effective and continuous control of coasts, it is also necessary to select the most accurate systems that will transmit the data obtained from them to the land.

Because, although many wireless systems can be used today for the transmission of coastal data, it is necessary to take into account both the initial installation costs and the communication costs. In line with these evaluations, it has been evaluated that the most suitable wireless communication system for data transmission from the sensors planned to be installed on the shore to the land is the AIS (automatic ship identification system) system, considering the installation and operating costs.

Declaration of Contribution of Researchers

The authors' contribution rates to the study are equal.

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Conflict of Interest Statement

There is no conflict of interest with any institution or person within the scope of the study.

References

Acarer, T. (2016). *Amatör Denizcik El Kitabı.* İstanbul: Boyut Yayıncılık ve Tic. A.Ş.

Acarer, T. (2018). VHF EPIRB Cihazı ile İlgili Mevzuatın İncelenmesi ve Alternatif Mevzuat Önerileri. *Social Sciences Research Journal*, 7(2), pp. 126-150, ISSN: 2147-5237 126.

Acarer, T. (2021). *Developments in the IT Sector and New Communication Opportunities for the Management of Businesses.* Ankara: Gece Kitaplığı. ISBN: 9786258449167.

Acarer, T. (2023). Endüstri'deki Gelişmelerin Denizcilik İşletmelerine Ait Gemilerin Yönetiminde Temin Ettiği Yeni Olanaklar Ve İnsansız Gemiler. *Mersin Üniversitesi Denizcilik ve Lojistik Araştırmaları Dergisi*, pp. 122-153, E-ISSN: 2687-6604.

Acarer, T. (2024). The Share of Data in Maritime Communications is Increasing. *Turkish Journal of Maritime and Marine Sciences*, 10(*Special Issue*: 1), 62-80. https://doi.org/10.52998/trjmms.1523871

Čačković, V. (2019). 5G today: Trends and Insights. *17th International Conference "Regulatory Activity in the Electronic Communications Sector"*, Budva, p.1. (Accessed on 24.04.2025). https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2019/Regulatory%20Forum/4.%20ERICSSON%20NIKOLA%20TESLA_Vanesa%20%C4%8Ca%C4%8Dkovi%C4%87_5G%20today,%20Trends%20and%20Insights.pdf

Demir, C. (2009). Maritime English. Kocaeli: *Akademi Denizcilik*.

Ece, N. J. (2018). Uluslararası Ticaretin Geleceği İnsansız Gemiler: GZFT Analizi ve Hukuki Boyutları. *Dokuz Eylül Üniversitesi Denizcilik Fakültesi Dergisi*, 10(2), 279-302. https://doi.org/10.18613/deudfd.495774

Ekinalan, T., Acarer, T. and Özkan, P. (2020). *GMDSS El Kitabı.* İstanbul: Elif Reklam Basım Sanatları San.

Fulser, B. (2015). Kombine Taşımacılık ve Türkiye Uygulamaları. İstanbul: *İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü.*

Hesse, M. and Rodrigue, J.P. (2004). The transport geography of logistics and freight distribution. *Journal of Transport Geography* 12 (2004) 171–184.

Kaptan, M., and Uğurlu, Ö. (2022). Elektronik seyir cihazlarının deniz kazalarına etkileri. *Aquatic Research*, 5(1), 89-98. https://doi.org/10.3153/AR22008

Kögmen, Z. (2014). Karayolu Taşımacılığının Diğer Taşımacılık Modlarıyla Karşılaştırılması ve Sağladığı Avantajlar. *Ulaştırma ve Haberleşme Uzmanlığı Tezi. Ankara***.**

Muslu, A. (2018). Deniz Turizminin Gelişimi İçin Yönetişim İhtiyacı: Bodrum Bölgesinde Nitel Bir Araştırma. *Dokuz Eylül Üniversitesi Denizcilik Fakültesi Dergisi*, 10(2), pp. 183-210. https://doi.org/10.18613/deudfd.495776

Reinsel, D., Gantz, J. and Rydning, J. (2018). The Digitization of the World from Edge to Core. *IDC (International Data Corporation) White Paper*, #US44413318, p.6. (Accessed on 24.04.2025). https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf

Saka, M., and Çetin, O. (2019). Research of a Dry Port Which Can Support Container Transportation from Kocaeli Ports in Terms of Possibilities and Capabilities. *International Journal of Engineering and Innovative Research* 1(1), 35-48. https://dergipark.org.tr/en/pub/ijeir/issue/43843/590124.

Saka, M. and Cetin, O. (2020). Comparing two judgment scales of AHP with a case study: reaching a decision on a dry port location. *WMU J Marit Affairs* 19, 427–461. https://doi.org/10.1007/s13437-020-00218-8.

Sucu, İ. (2019). Yapay Zekanın Toplum Üzerindeki Etkisi ve Yapay Zeka (A.I.) Filmi Bağlamında Yapay Zekaya Bakış. *Uluslararası Ders Kitapları ve Eğitim Materyalleri Dergisi*, 2(2), 203-215.

UNCTAD (United Nations Conference on Trade and Development). (2019). *Review of Maritime Transport* 2019. New York: UNCTAD/RMT/2019, p. 4. ISBN 978 92-1-112958-8.

UNCTAD. (2024). *Review of Maritime Transport* 2024. New York: UNCTAD/RMT/2024, p. 6. ISBN 978 92-1-003206-3.

Usluer, H. B. (2015). Liman Planlama Ve Geliştirmede Deniz Bilimlerinin Önemi. *II. Ulusal Liman Kongresi,* (pp. 330-343). İzmir.

WMU (World Maritime University). (2019). Transport 2040: automation, technology, employment-the future of work. *Reports. 58*. "https://commons.wmu.se/lib_reports/58".

Yang, T., Zheng, Z., Liang, H., Deng, R., Cheng N. and Shen, X. (2015). "Green Energy and Content-Aware Data Transmissions in Maritime Wireless Communication Networks," in *IEEE Transactions on Intelligent Transportation Systems*, vol. 16, no. 2, pp. 751-762, doi: 10.1109/TITS.2014.2343958.

Yılmaz, E. (1990). Konteyner ve Konteyner Taşımacılığı. *İstanbul: Deniz Ticareti.*

Yılmaz, L. and Acarer T. (2014). *Küresel Denizde Tehlike ve Emniyet Sistemi (GMDSS), Genel Telsiz Operatör Ehliyeti (GOC).* İstanbul: Akademi Yayınları.