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December 2022

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Assoc. Prof. Dr. Gülbin Çetinkale Demirkan

Assoc. Prof. Dr. Sertaç GÜNGÖR

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CHAPTER 5

MONITORING COMMERCIAL MARINE TRAFFIC VIA GEOGRAPHICAL INFORMATION SYSTEM CASE OF AEGEAN SEA[1]

Tekin ERDOĞAN[2], Muhammed AYDOĞAN[3]

1 This article has been derived from "Monitoring Commercial Marine Traffic Via Geographical Information System-Case Of Aegean Sea" which is the post graduate thesis of Tekin ERDOĞAN under supervision of Muhammed AYDOĞAN, at The Graduate School of Natural and Applied Sciences of Dokuz Eylul University, Department of Geographical Information Systems; (Erdoğan, 2012).

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1. Introduction

The emergence of maritime relationships of societies dependent on water and water resources for the continuity and development of their existence is due to their concerns about utilizing large waters. The geographical and natural conditions of individuals, communities, and societies turned their maritime matters into self-interests and then such self-interests have been diversified and expanded. This is indicated by maritime transport accounting for 90% of the total transportation volume worldwide.

Maritime trade, which is the purpose of this study, is based upon the transport and exchange of commodities from one coast to another using accessible, cheap, safe marine transportation facilities. However, it has become a passenger and cargo transportation trade primarily over time.

With its growing economy and increasing trade capacity, Türkiye has become an important country with potential maritime trade within its region. Maritime trade is vital for Türkiye, a developing country with an increasing import and export volume; thus, it should be improved and increased. Due to its geopolitical position, Türkiye is a junction area between three continents. Hence, world maritime trade is essential not only at a national level but also at an international level. The Aegean Sea, with significant underground resources, ports, and many gulfs, is a junction between the Black Sea and the Mediterranean. However, the safe management of maritime trade in the Aegean Sea is a complex issue due to problems concerning continental shelf, etc.

This study examined how to utilize emerging technologies to clarify the rights and duties of different components within a given area and create an active control system to overcome complex management problems by using Geographical Information Systems. In line with this purpose, this study investigated the most effective method to monitor the whole sea surface for 24 hours uninterruptedly using the integrated maritime surveillance system. This study also sought answers to questions concerning the type of radars used during naval surveillance operations, the positioning of radars to ensure the most effective and maximum coverage area, the required number of radars, the coverage area of radars in the Aegean Sea, and the coverage ratio of radars under adverse conditions. DTED1 (Digital Terrain Elevation Data) maps were used during these investigations. These maps contain digital terrain elevation data and have one point per 100 meters sensitivity rate. Furthermore, the viewshed analyses were conducted using Global Mapper software. Based on these analyses, necessary propositions and results were developed.

2. Maritime Security for Türkiye

Turkish straits, one of the essential waterways in the world with no alternative, are the internal waters of Türkiye. Moreover Türkiye also controls the Suez Canal with many vital waterways. Therefore, any threat of terrorism in such geography, whether aimed at Türkiye or not, will directly affect Türkiye's security and economy.

Today, commercial maritime transport is much more freely and safely carried out all across the world when compared to road and air transport. Therefore, any interruption of maritime transport for some reason or failure to maintain its security may cause significant damage to the global economy. For example, oil prices almost doubled after both parties attacked oil tankers in the Persian Gulf during the Iran-Iraq war.

"Eight out of nine vital waterways among the most important 18 waterways in the world pass through the Mediterranean." (Davutoğlu, 2002) The blockage of the relevant eight waterways in some way will severely hamper the world maritime trade and oil transportation.

Türkiye is a country which has caught and maintained the growth trend and depends on the sea for 85% of its trade activities. Thus, it should develop strategic plans related to the use of maritime trade routes of great importance for Türkiye and maintain its security. This is a must not only for Türkiye's self-interests but also for other countries' interests.

3. Activities For Monitoring Marine Traffic

3.1 Turkish Straits Vessel Traffic Services

Turkish Straits Vessel Traffic Services (TSVTS) was commissioned on December 30, 2003, to improve the safety of navigation, protection of life, property, and environment in the Turkish Straits, to monitor and manage marine traffic in the respective area, and to reduce the risks of possible maritime accidents. In addition to both the Dardanelles and Bosphorus, the Sea of Marmara, with an attachment of 3 Traffic Monitoring Stations (TMS) (Armutlu TMS, Bozcaada TMS and Şarköy TMS), was also included in the system on July 02, 2008, to monitor the vessel traffic running within the traffic separation scheme in the Sea of Marmara. Figure 1 shows the integration of the Sea of Marmara into the central system, covering the whole area within the traffic separation outline of Marmara and the 20-mile area located on the west and southwest of Bozcaada (Tenedos). With this integration, it is now possible to continuously monitor the vessel traffic from the Aegean Sea to the Black Sea (TCS, 2010).

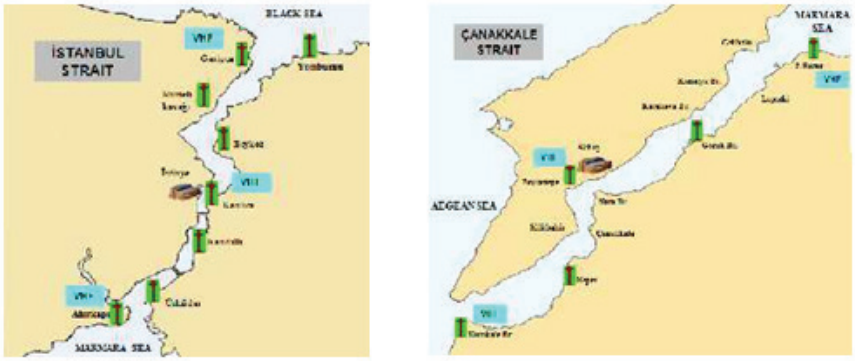


Figure 1: *TSVTS and Traffic Monitoring Stations (TCS, 2010)*

3.2 The Project for the Vessel Traffic Management System

The bodies of water that make up the Turkish Straits are the Dardanelles (37 miles), the Sea of Marmara (110 miles) and the Bosphorus (17 miles). The Turkish Straits, stretching from the Black Sea to the Aegean, with a total length of 164 nautical miles, have no alternative and thus are of high importance for the economies of all countries, especially the Black Sea countries.(TBGTH, nd, http://www.kegki.gov.tr/)

The Project for the Vessel Traffic Management System is intended to install a system which collects information on any vessel movement in the Turkish Territorial Waters (whether within the area of Vessel Traffic Services or not) to improve the safety of navigation in the areas of İzmit, İzmir, İskenderun, and Mersin where the vessel traffic is heavy and dangerous, a large part in hazardous cargos is handled, and passenger transportation is carried out. (TCS, 2010)

3.3 Automatic Identification System (AIS)

An Automatic Identification System (AIS) is an automated tracking system used on ships to identify and locate vessels within a close range.

The International Convention for the Safety of Life at Sea (SOLAS) adopted by the International Maritime Organization (IMO) requires AIS to be fitted aboard international voyaging ships with gross tonnage (GT) of 300 or more and all passenger ships regardless of size. The AIS operates on VHF marine frequencies. AIS transponders broadcast information at VHF marine channels 87B (161.975 MHz) and 88B (162.025 MHz) using Gaussian minimum shift keying (GMSK) modulation. As the sound is unclear, the AIS requires a receiver or transponder to process the sound (GemiTrafik.com, 2011) .

The vessels using the AIS system (and VTS stations regulating the

marine traffic) can display a great deal of detailed information provided by AIS equipment, such as unique identification, call signs, coordinates, course, speed, vessel dimensions, destination port, and the estimated time of arrival. AIS covers a shorter range than the radar systems used on ships but provides much more detailed information.

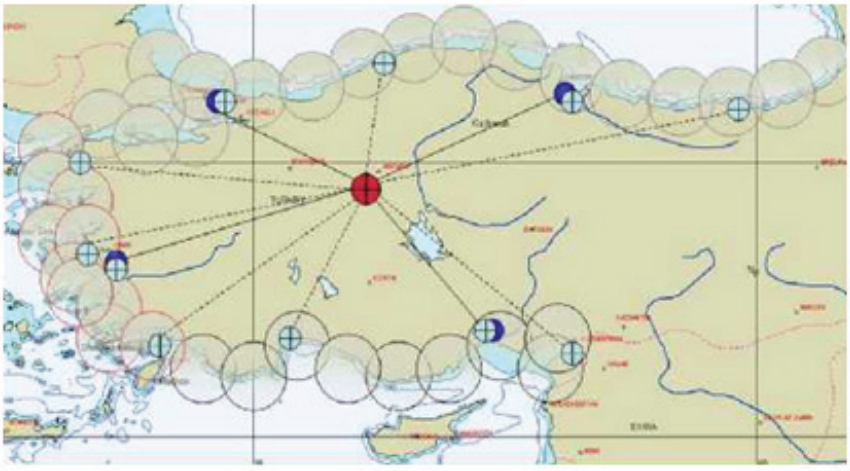


Figure 2: *AIS terminals and their coverage (Kuloğlu, 2008)*

The AIS system can be used effectively for national security by the relevant institutions and organizations of Türkiye to interrogate ships navigating in the surrounding seas and narrow waters such as straits and inland waters, and to automatically get necessary information related to boats such as unique identification, speed, position, etc. Furthermore, the real-time tracking of civilian vessels navigating the sea is imperative for effectively performing tasks and activities such as maritime search and rescue, combating trafficking, and preventing marine pollution. (TCS, 2010). Therefore, the AIS system serves many purposes, including:

- Maintaining more secure and safe navigation on Turkish coasts
- Preventing maritime accidents and contributing to emergency response operations during maritime accidents
- Improving effectiveness in search and rescue activities
- Preventing trafficking and illegal immigration
- Controlling fishery activities

(TCS, 2010)

3.4 Long-Range Identification and Tracking System

Maritime security has become one of the major issues after the September 11 attacks in the USA. Considering that the AIS system has the capability of tracking only ships navigating at a close range from the coast, a project for Long Range Identification and Tracking (LRIT)

The IMO developed a system to track vessels at a longer distance from the coast (beyond AIS coverage) as terrorists target maritime transport. (LRIT System, nd, http://www.polestarglobal.com)

The LRIT project applies to the following ship types engaged on international voyages:

- All passenger ships, including high-speed craft,
- Cargo ships, including the high-speed vessel of 300 gross tonnages and above, and
- Mobile offshore drilling units.

In this scope, IMO member countries can get long-range identification and tracking information related to ships for security and other aspects agreed upon by IMO and the responsibilities of the flag, port or coastal countries have been identified.

Thanks to the LRIT system, within the regulations adopted by the IMO, a country will be able to interrogate:

- Ships flying their flag
- Inbound and outbound vessels in its port
- Vessels navigating at a distance of up to 1000-mile from their coast
- Vessels navigating for search and rescue purposes

3.5 Cospas-Sarsat System

Cospas-Sarsat (COSPAS: Cosmicheskaya Sistyema Poiska Avariynich Sudov- Space System for the Search of Vessels in Distress – SARSAT: Search And Rescue Satellite Aided Tracking) is an international satellite-based search and rescue (SAR) distress alert detection and information distribution system established by Canada, France, the United States, and the former Soviet Union in 1979. It is best known as the system that detects and locates emergency beacons activated at the frequencies 121.5 MHz, 243 MHz or 406 MHz by aircraft, ships, and backcountry hikers in distress and then starts to search and rescue operations as soon as possible. Türkiye has been involved in COSPAS-SARSAT system in the capacity of Ground Segment Provider as from June 11, 2005 (TCS, 2010)

4. Integrated Maritime Surveillance System

The continuous surveillance of borders, including maritime boundaries, of a country like Türkiye, surrounded by seas on three sides, is critical concerning security and national defence. Furthermore, continuous surveillance is also necessary for various reasons, such as terrorism, smuggling, illegal fishing, environmental protection, fishery activities, oceanography, and illegal immigration. Maritime surveillance systems play a crucial role for a country like Türkiye, which has substantial potential for maritime trade.

The utilization and improvement of maritime trade are of vital importance to Türkiye, which is the 16th largest economy of the world and an essential power in its region, due to its strategic position surrounded by seas on three sides, its increasing import and export volumes, and its rapidly developing country profile. Therefore, Türkiye must monitor its coasts, especially the Aegean Sea with numerous gulfs, cliffs, and thousands of nested islands.

Considering the chronic disputes with the neighboring countries, the importance of surveillance and monitoring traffic in the Aegean Sea for Türkiye becomes more apparent. Türkiye, located at the junction point of three continents, is an essential route for illegal immigration and trafficking via the Aegean Sea into the European Union, with a high level of welfare. Therefore, it is necessary to maintain the safe execution, monitoring, and control of maritime trade on coasts.

The Aegean Sea, with a coastline of 3484 kilometers, excluding the geographical formations such as islands, islets and rocks whose sovereignty has not been transferred by agreements, is not only of commercial importance for Türkiye but also of great importance for other world countries. Furthermore, the Aegean Sea is a special zone where even minor events draw public's attention. Thus, it is targeted by terrorists and interest groups aiming to create regional instability. Considering this, the Aegean Sea, where terrorist actions can make a tremendous and quick impact, should be protected meticulously and controlled without causing any crisis or allowing terrorist activities.

The surveillance of maritime boundaries is a must for Türkiye, which depends on its ports for 90% of its foreign trade activities in parallel with its increasing tourism revenues and growing economy. In addition, Türkiye, which has ongoing territorial disputes with Greece, highly needs surveillance systems for security and defense purposes to determine border violations and take necessary measures to respond to emergencies, such as accidents, in the areas of responsibility.

4.1 Surveillance of Aegean Sea by Microwave Radar

"Microwaves" describe electromagnetic waves with a wavelength of 1 cm to 1 m. The corresponding frequency range is 300 MHz up to 30 GHz. Electromagnetic waves with a 1 to 10 mm wavelength are called millimeter waves. The infrared radiation spectrum comprises electromagnetic waves with a wavelength of 1 μm to 1 mm. Beyond the infrared scope is the visible optical spectrum, the ultraviolet spectrum, and finally X-Rays. Several classification schemes are used to designate electromagnetic spectrum and frequency bands. The term "microwave engineering" is generally the engineering and design of information-handling systems in the frequency range from 1 to 100 GHz corresponding to a wavelength of 30 cm to 3 mm. The characteristic feature of microwave technology is the short wavelengths involved (Görür, 1996).

The use of microwave radars is limited to the horizon line. Therefore, for example, the field of view does not exceed 40 km even at a platform 40-50 m high from the ground. Microwave radars are deployed on aircraft or high hills to cover larger areas. During World War Second and shortly afterwards, the microwave was almost synonymous with radar because of the great stimulus given to the development of microwave systems due to the need for high-resolution radar capable of detecting and locating enemy aircraft and ships. Even today, many varied forms, such as weather-detecting radar, missile-tracking radar, missile-guidance radar, airport traffic-control radar, fire-control radar, etc., use a considerable part of microwave frequencies. As the propagation of microwaves is effective along the line-of-sight, it requires high towers with reflector or lens-type antennas as repeater stations installed at certain intervals along the communication path. Frequent travellers often see these links because of their regular use by highway authorities, utility companies, and television networks. A further means of communication by microwaves is using satellites as microwave relay stations. (Görür, 1996)

4.2 Purpose of Integrated Maritime Surveillance Systems

The objectives and functions of Integrated Maritime Surveillance Systems are as follows:

- To control coastal waters and maritime boundaries,
- To control marine traffic,
- To ensure the effective prevention of any form of smuggling and illegal immigration,
- To improve the effectiveness of marine search and rescue operations,

- To control fishery activities and maritime resources,
- To enhance the effectiveness of data and intelligence-gathering activities,
- To provide effective C4ISR systems (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance),
- To build a Maritime Picture and a Recognized Maritime Picture.

4.3 Components of the Integrated Maritime Surveillance System

Surface Wave Radar: The type of radar used varies according to the requirements. Two types of radars, including groundwave HF-VHF and microwave radars, are used in surveillance systems depending on the features of the area chosen for surveillance.

Other Sensors and Information Sources: The ships detected by radars may be identified using a database containing the records obtained via the AIS system of those ships registered to IMO. Furthermore, even webcam marine images published online may be used as an information source to build a Recognized Maritime Picture.

Data Fusion Engine: Data fusion engine is the core of the IMS system. Utilizing fusion, different sources of information are combined to improve the existing surveillance capability. The most obvious illustration of fusion is using various sensors to detect a target or build a layered picture. A central data fusion engine automatically correlates target detections or tracks from HF and microwave radars. This function is called a "correlator". It is used to reduce two or more channels, derived from other sources whenever HF radar is not in use, to one way in real-time and in an accurate manner. (Ding & Kannappan & Benameur& Farooq & Kirubarajan, 2003)

Data Distribution Server: Data Distribution Server provides all necessary data and services for authorized clients.

IMS Administration: Manages changing configurations, operating and non-operating conditions of IMS system, user accounts and security, and data areas, and maintains logs and backups and retrieves them. Furthermore, it provides a Recognized Maritime Picture to the authorized clients within the scope of their rights.

Communications Infrastructure of the IMS: An architecture of data transfer infrastructure is constructed (Figure 3). Satellite systems may be used for data transfer on land at high points where microwave radars are deployed.

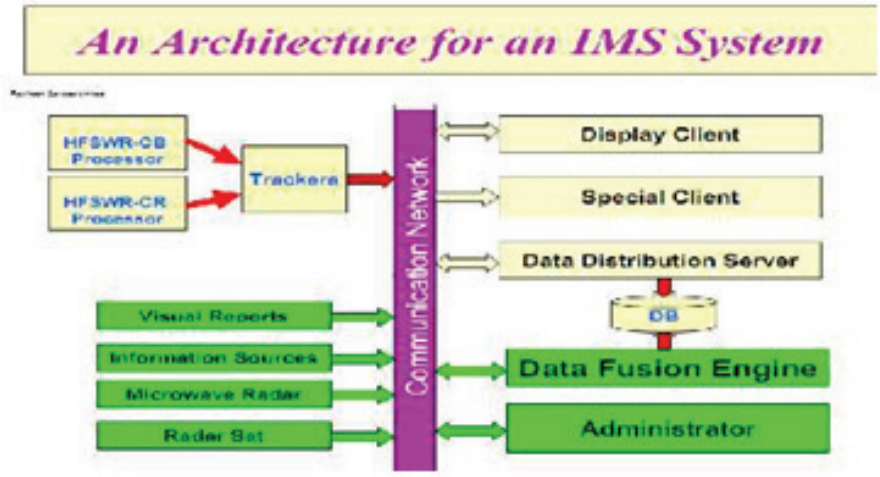


Figure 3: *The proposed IMS architecture (Ding & Kannappan & Benameur& Farooq & Kirubarajan, 2003)*

5. Viewshed Analyses Of Maritime Surveillance Radars

Radars are one of the significant elements of integrated maritime surveillance systems. The target detections or tracks derived from radars help build a recognized maritime picture with other information sources. This picture contains numerous elements, including trade ships, fishery ships, and passenger ships. It will help the officials to control commercial traffic and combat trafficking and respond to emergencies. To build the most effective recognized maritime picture, Microwave X-Band radars, whose coverage is limited to the horizon line, should be deployed at the highest points with the best line of sight in the Aegean Region. The Aegean Sea has numerous islands, so HF radars were not used in this case as they lose conductivity on land.

The Aegean Sea, having different features from the Black Sea, the Mediterranean, the Sea of Marmara, and even most of the world, has been chosen for our analyses as it has numerous cliffs, bays, and thousands of islands. Monitoring the commercial traffic in the Aegean Sea, radar viewshed analyses were made by Global Mapper software using DTED1 Maps between the latitudes E-20 and E-36 and between N-35 and N-41.

The purpose is to simulate the change in the capability of monitoring the current situation in case radars of different types, which were placed at different positions on the maps built via GIS tools. For this purpose, creating a structure to model the topography on digital base maps was necessary. Therefore, in the first stage of the application, different base maps

used for interpreting elevation data were handled, and then the possible analyses on such maps were assessed.

5. 1 Viewshed Analysis with a Microwave Radar

X-Band radars, operating in the frequency range of 8 to 12 GHz, are used for maritime surveillance (Camponeschi, M., Bevilacqua, A., Tiebout, M., & Neviani, A., 2012). In addition, most companies worldwide produce X-Band Radars for military and civilian purposes. Therefore, within the scope of this study, a standard coastal surveillance radar was taken into consideration and analyses were carried out considering the technical specifications of this radar.

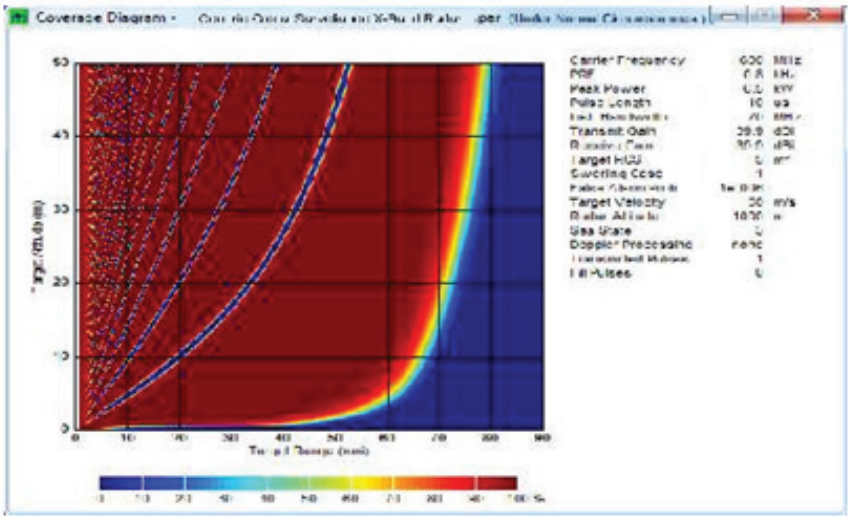


Figure 4: *Coverage diagram of a generic coastal watcher X band radar at a radar altitude of 1000 meters*

As shown in Figure 4, the coverage of a Generic Coastal Watcher X Band Radar, operating at a frequency of 600 MHz and deployed at an altitude of 1000 meters, is approximately **65 nautical miles** at the sea surface (Dowdeswell, J. A., Whittington, R. J., & Hodgkins, R., 1992). This result was obtained at an air temperature of 15° C, under still wind and a humidity of 70%. Therefore, in the scope of this study, the viewshed analyses under normal conditions were performed based on a radar coverage of 65 nautical miles.

Radar cross-sectional area and, thus, radar coverage are reduced under adverse conditions such as rain, moisture, wind, fog, and noise. Figure 5 shows the behaviour of a Standard Maritime Surveillance Microwave Radar under adverse conditions.

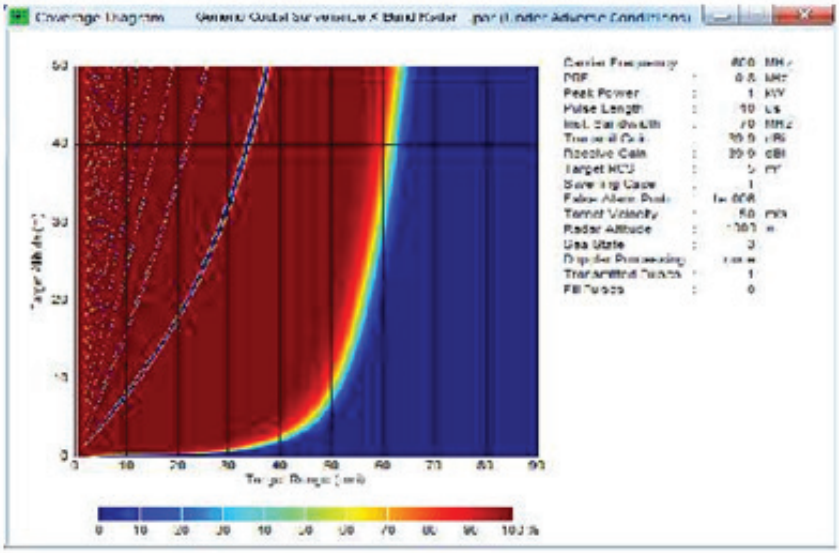


Figure 5: *Coverage diagram of generic coastal watcher X band radar at a radar altitude of 1000 meters*

As shown in Figure 5, the coverage of a Generic Coastal Watcher X Band Radar is approximately **50 nautical miles** at an altitude of 1000 meters. Therefore, in the scope of this study, the viewshed analyses under adverse conditions were performed based on a radar coverage of 50 nautical miles.

5.2 Viewshed Analysis of Territorial Waters

As shown in Figure 4, a Generic Coastal Watcher Radar covers an area of 65 nautical miles at a radar altitude of 1000 meters. Figure 6 shows the viewshed analysis of the Turkish territorial waters with radars deployed at the most appropriate positions according to the 6-mile limit.

Radar 1, with an antenna height of 10 meters, was deployed at an altitude of 694 meters in the Dardanelles region to cover the north Aegean Sea region. Figure 6 shows the coverage of Radar 1, which covers the entrance to the Dardanelles strait and a large part of the north Aegean Sea region. Radar 1 has a field of view of 47.9% surrounding the sea surface in a circle of 360 degrees. This result indicates territorial waters of Türkiye and some of the high seas within the related region of interest are covered by Radar 1.

Radar 2, with an antenna height of 10 meters, was deployed at an altitude of 1206 meters in the Izmir region to cover the middle Aegean Sea region. Radar 2 has a field of view of 36.8% surrounding the sea surface in a circle of 360 degrees. The cross-sectional area of Radar 2, covering the

Izmir Region and the middle Aegean Sea region, is lower than the north Aegean Sea region due to the higher number of islands, islets, cliffs, and gulfs in the coverage area of Radar 2. This analysis indicates that not all but a large part of the territorial waters of Türkiye and high seas within the related region of interest are covered by Radar 2, with a coverage of 65 nautical miles under normal conditions.

Radar 3, with an antenna height of 10 meters, was deployed at 1145 meters in the Marmaris region to cover the south Aegean Sea region. Radar 3 has a field of view of 45.5% surrounding the sea surface in a circle of 360 degrees. Radar 3, deployed at a lower altitude than Radar 2 and substituting the eastern Mediterranean region and the south Aegean Sea region with more islands, islets, cliffs and gulfs, as compared to the middle Aegean Sea region, does not have a coverage of less than that of Radar 2. The result is the favourable position of Radar 3 and deployment at a much higher point than the surrounding elevations. The change indicates that almost all territorial waters of Türkiye and the high seas within the related region of interest are covered by Radar 3, with a coverage of 65 nautical miles under normal conditions.

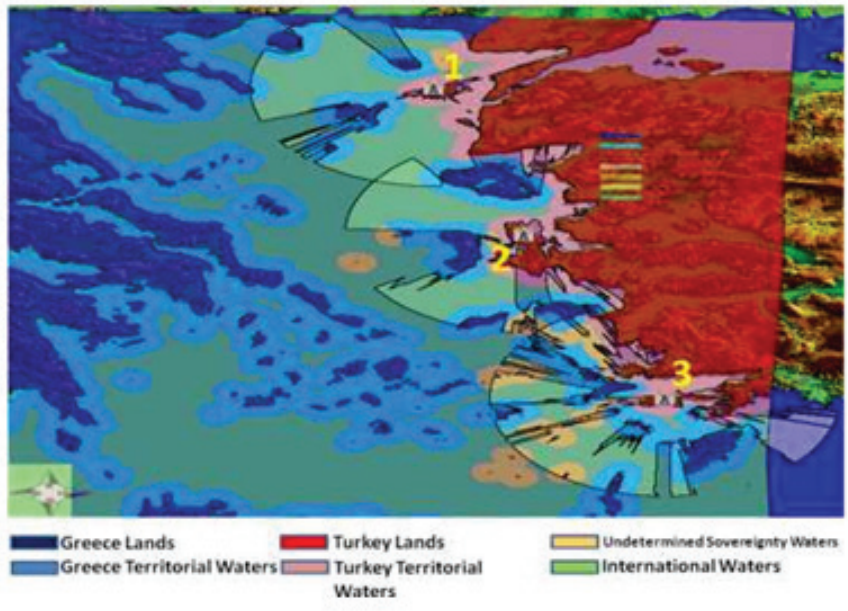


Figure 6: *Viewshed analysis of territorial waters under normal conditions*

Consequently, it is seen that almost all Turkish territorial waters in the Aegean Sea region and a large part of the high seas in this area are covered by three microwave radars with a coverage of 65 nautical miles under normal conditions. Furthermore, the study reveals radars should deploy at the best field viewpoint rather than at the peak point.

5.3.Viewshed Analysis of Territorial Waters under Adverse Conditions

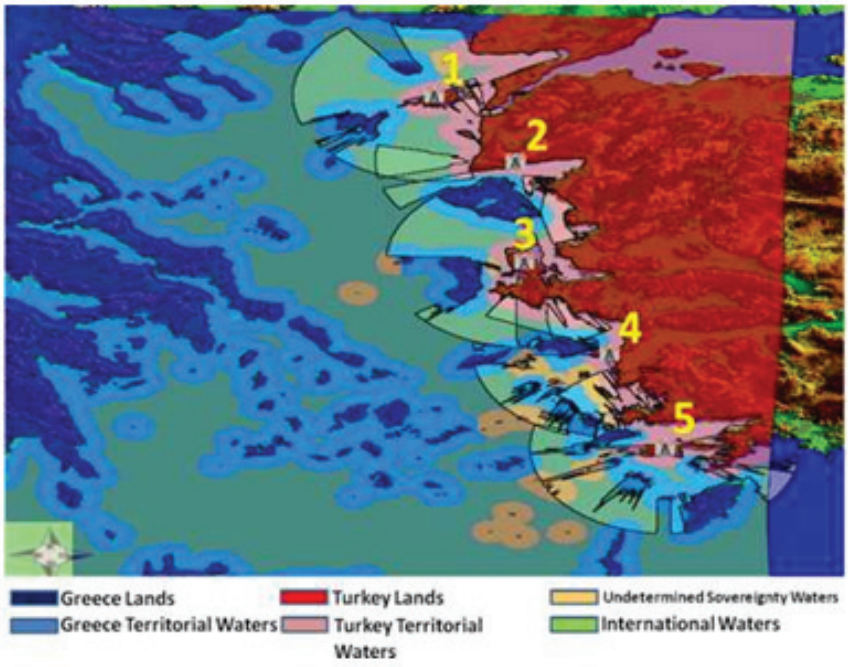


***Figure** 7 Viewshed analysis of territorial waters under adverse conditions*

Figure 7 shows radars with a cross-sectional area of 50 nm. It has been demonstrated that the coverage provided by three radars used in the analyses conducted under normal conditions was insufficient to cover the Turkish territorial waters under adverse conditions. Therefore, two more radars were deployed in addition to three radars with an optimum performance under normal conditions. These radar points are numbered 2 and 4 in Figure 7.

Consequently, it is seen that all Turkish territorial and a large part of the high seas within the related interest of the region are covered with the deployment of two additional radars. Especially, Radar 2 was deployed to provide complete coverage inside the gulf.

6. Conclusion

The Aegean Sea, having different features concerning geographical difficulties and diversity, was chosen as the subject of our study. Furthermore, a methodology was developed to correct the deployment of radars as one of the significant components of the IMS system. Also, the applicability of this methodology to other regions was evaluated.

The Aegean Sea is a valuable asset for Türkiye's economy, and its surveillance is vital for security. However, this critical region is targeted by terrorists due to its location on international transit routes and the related ongoing disputes between Türkiye and Greece. Therefore, the safety and security of commercial traffic in this region should be controlled. Furthermore, the Aegean Sea is on a route for illegal immigration into EU countries. Today, 90.4% of worldwide crude oil production is transported by sea. Therefore, it is vital to maintain the safe navigation of ships carrying dangerous cargo as Türkiye is close to the energy corridors, namely Russia, Azerbaijani and Arabian countries, as energy exporters, and to the EU countries, as energy importers. For any possible accident, the scene of the accident should exactly be located and immediately reported to the relevant security units.

Due to such reasons, the construction of a recognized maritime picture, which enables monitoring of commercial traffic in Türkiye's territorial waters, especially in the Aegean region, is of considerable importance. As a result of evaluations in the scope of this study, Integrated Maritime Surveillance (IMS) system has been chosen as the most effective method for monitoring the sea surface. This study describes the architecture and features of the IMS system. The primary objective of the IMS system is to construct a recognized maritime picture.

To build a comprehensive maritime trade picture, the required number and deployment locations of radars, one of the most critical components of the IMS system, and their coverage under different conditions were examined in the scope of our study. The breadth of the area chosen for surveillance and the features and positions of radars determine the number of radars for coverage processes. It is assumed that the best coverage is provided by deploying microwave radars, whose range is limited to the horizon line, at the highest possible point. However, numerous deployment attempts in this study's scope have revealed that the highest point does not have the best angle of vision (coverage).

X-Band radars are sufficient to monitor the territorial waters of Türkiye and international transit routes within the respective region of interest. Maritime control is maintained, thanks to the high resolution of X-Band radars, meticulously. Moreover, a system backup can be supported using mobile X-Band radars for situations such as war, disaster etc. Mobile X-Band radars can provide the desired focus, and the outputs can be evaluated within the scope of the IMS system. Therefore, it may be helpful to develop and use such radars.

Thanks to radar stations, a meaningful regional maritime picture will be built by fusing data from AIS and other information sources

and thus pooling them in a single center. Assuming that our coverage area is 65 nautical miles under normal conditions, it is concluded that additional information sources, such as LRIT and COSPAS-SARSAT, are required to cover more extensive regions, such as search and rescue areas. Furthermore, it is shown that the recognized maritime picture will provide meaningful data when combined with target detections and tracks derived from radars.It is evaluated that more precise analyses may be conducted in the case of DTED Level 2 and DTED Level 3 maps, which are more accurate than the DTED Level 1 map used in our studies.

The security of Turkey's territorial waters is more important than ever these days. The territorial waters problems with Turkey and its neighbours have been brought to the international courts. In addition, irregular migration, illegal trade, accidents, and sudden interventions make it essential for Turkey to monitor its territorial waters carefully and analyze this traffic in detail. In this context, the Aegean Sea is the region that needs to be examined most straightforwardly and effectively in order to obtain a picture of commercial maritime traffic. This study explains how the infrastructure and information technology architecture should be in order to create a maritime traffic picture that will not leave a blind area and will be watched most effectively. It also examines where the radars, which are the information providers of this fission system to be created, should be positioned most effectively. Factors such as weather conditions, altitude, and visibility were considered, and the most optimal commercial sea traffic was analyzed.

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