DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

MONITORING COMMERCIAL MARINE TRAFFIC VIA GEOGRAPHICAL INFORMATION SYSTEM-CASE OF AEGEAN SEA

by

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March, 2012
İZMİR

MONITORING COMMERCIAL MARINE TRAFFIC VIA GEOGRAPHICAL INFORMATION SYSTEM-CASE OF AEGEAN SEA

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by

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M.Sc THESIS EXAMINATION RESULT FORM

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MONITORING COMMERCIAL MARINE TRAFFIC VIA GEOGRAPHICAL INFORMATION SYSTEM-CASE OF AEGEAN SEA

ABSTRACT

Maritime transport accounts for 90 percent of the total volume of world trade on a ton-mile basis and 80 percent on a value and quantity basis. Today, 90.4 percent of the crude oil production amounting to 66.1 million barrels/day is transported by sea. Thinking that the petroleum history is directly associated with the world war history, the importance of maritime security becomes apparent. Furthermore, the maritime transport and the economies of countries are complementary of each other. The commercial traffic of the Aegean Sea Region, which is located on the transition route of energy corridors, should be managed in a safe and controlled manner. The installation of an integrated maritime surveillance system will serve for this purpose. This study includes the components and information sources used in the architecture of the surveillance system. Moreover, the viewshed analyses, as one of the most important detection sources of the Integrated Maritime Surveillance System, were made using to digital elevation models assistance with Geographical Information Systems and possible deployment positions of radars were evaluated in the scope of this study.

Keywords: Maritime trade, GIS, radar, integrated maritime surveillance (IMS)

COĞRAFİ BİLGİ SİSTEMLERİ İLE TİCARİ DENİZ TRAFİĞİNİ İZLEME – EGE DENİZİ ÖRNEĞİ

ÖZ

Tüm dünya ticaretinin ton-mil bazında yüzde 90'ı, değer ve miktar bazında yüzde 80'i, deniz yolu ile taşınmaktadır. Günümüzde ortalama 66.1 milyon varil/gün olarak gerçekleşen ham petrol üretiminin yüzde 90,4'ü da deniz yolu ile taşınmaktadır. Petrol tarihi ile dünya savaş tarihi doğrudan ilişkili olduğu düşünüldüğünde deniz yollarının güvenliğinin önemi ortaya çıkmaktadır. Ayrıca deniz taşımacılığı ile ülkelerin ekonomileri bir birlerinin tamamlayıcısı durumundadır. Enerji koridorlarının geçiş güzergâhında olan Ege Denizi Bölgesinin ticari trafiğinin, güvenli ve kontrollü olarak sağlanması gerekmektedir. Tesis edilen tümleşik bir deniz gözetleme sistemi bu amaca hizmet edecektir. Tesis edilecek Gözetleme sistemi mimarisi içerisinde hangi unsurların ve bilgi kaynakların olacağı çalışmamızda ele alınmıştır. Ayrıca analizlerimizle Tümleşik Gözetleme Sisteminin en önemli tespit kaynaklarından olan radarların kaplama analizleri Coğrafi Bilgi Sistemleri yardımıyla sayısal yükseklik modelleri kullanılarak yapılmıştır, radarların konuşlanabileceği olası konumlar değerlendirilmiştir.

Anahtar Sözcükler: Deniz ticareti, CBS, radar, tümleşik deniz gözetleme (IMS)

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CHAPTER ONE
INTRODUCTION

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

Maritime Trade, which is the purpose of this study, is based upon the transport and exchange of commodities from one coast to another by means of easy, cheap and safe marine transportation facilities. However, it has turned into mostly a passenger and cargo transportation trade over time.

With its growing economy and increasing trade capacity, Turkey has become an important country with a potential for maritime trade within its region. Maritime trade is vital for Turkey, a developing country with an increasing import and export volume, and thus it should necessarily be improved and increased. Due to its geopolitical position, Turkey is a junction area between three continents, and thus the world maritime trade being important not only at a national level but also at an international level. The Aegean Sea, with important underground resources, ports, and a great number of gulfs, is a junction point 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.

The purpose of this study is to examine how to utilize emerging technologies for clarifying the rights and duties of different components within a given area and creating an active control system to overcome complex management problems by using Geographical Information Systems. In line with this purpose, this study investigates the most effective method to monitor the whole sea surface for 24 hours uninterruptedly by means of the integrated maritime surveillance system. This study also seeks for answers to questions concerning the type of radars used during maritime 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. During these investigations, DTED1 (Digital Terrain Elevation Data) maps were used. These maps contain digital terrain elevation data and have a sensitivity rate of one point per 100 meters Furthermore, the viewshed analyses were made by means of Global Mapper software. Based on these analyses, necessary propositions and results were developed.

CHAPTER TWO
AN OVERVIEW OF SECURITY CONCEPT AND A SECURITY PERCEPTION FOR TURKEY

The security concept applies to any course of action intended to "maintain and continue one's existence". First of all, the security has a purposeful meaning and the purpose of security within the framework of maintaining and continuing one's existence is to protect nations and individuals. The security perception applies to all social, national and international institutions, organizations, phenomena, and events since the security is directly associated with the purpose, and as the purpose changes or improves, the perception of internal and external threats is expanded, resulting in new security pursuits. The security also has similar meanings in international relations. All actors involved in the system have different security approaches and pursuits. The security concept and perception made sense after the World War Second and the relevant approaches have been developed. After the World War Second, the countries were fed up with destructions due to the warfare and established organizations to maintain lasting peace. Although the countries hoped for lasting peace after the World War Second, the threat of Cold War between the east and west blocks caused tension all over the world. However, this tension never turned into a large-scale and global hot war between parties. The balances of power shaped the international security throughout the Cold War. The underground resources, increasing energy requirements, trade volumes and trade routes, internal and external threats, and the geographical position of countries determine their security strategies. The security perception that is intended to protect the self-interests of nations has changed all over the world after the September 11 terrorist attacks and the security has evolved into a structure which has not only a national but also an international concern. In other words, it has gained a structure that serves to protect all interests of human and universe and makes a struggle for this. International security is necessary to establish and maintain peace and it serves for the world welfare and peace, rather than the self-interests of countries. Today, it is of more importance to prevent war than win it.

2.1 Maritime Security

Maritime transport accounts for 90% of the total volume of world trade on a ton-mile basis and 80% on a value and quantity basis. Today, 90.4% of the crude oil production amounting to 66.1 million barrels/day is transported by sea. Therefore, the world economy is affected by changes in the maritime transport and attempts to direct the development of the sector. Maritime transport still retains its important position in the economic balance sheets of countries due to its incomparable superiority over other sectors with regard to the available capacity, its advantage of long haul operation, and its low-price compared to other modes of transport. (TCS, 2010)

> *Yet their continued growth may create increasing competition for resources and capital with other economic powers, transnational corporations and international organizations. Heightened popular expectations and increased competition for resources, coupled with scarcity, may encourage nations to exert wider claims of sovereignty over greater expanses of ocean, waterways, and natural resources potentially resulting in conflict. (USA Navy, 2007)*

Especially, economic interests and threats necessitate maintaining the security of waterways and maritime borders for countries, whether coastal or land-locked. Accordingly, national and international security strategies are shaped in parallel with the maritime security that has a direct effect on the self-interests of countries. For a better understanding of the security concept, the following paragraphs include the aspects that shape security strategies and constitute a threat.

The acts of piracy and armed robbery against ships frequently encountered in the Gulf of Aden and off the coast of Somalia are of international concern and closely followed by the world community. The attacks in this zone have a direct effect on the world oil market and lead to the fluctuation of oil prices. In the review of the acts of piracy between January 1 and March 31, 2010, it is seen that pirates attack ships in a larger area by using different methods. Within this framework, in the light of the statistics of the International Maritime Bureau (IMB):

A total of 128 cases, comprising 34 ship hijacking attempts, 69 ship shooting events, 24 ship hijacking events, and 1 boarding attack were recorded in the Gulf of Aden;

A total of 98 cases, comprising 10 ship hijacking attempts, 1 boarding attack, 69 ship shooting events, and 31 ship hijacking events were reported off the coast of Somalia.

Maritime pirates, which have become the nightmare of seafarers in the Gulf of Aden, increasingly continue their activities despite all precautions. International Maritime Bureau (IMB) reports that pirates hijacked 26 ships, 21 of which off the coast of Somalia, and took 362 hostages in 2011. It is stated that pirates organized a total of 243 attacks in 2011 resulting in the death of 7 crew members. This figure corresponds to an 11 percent increase compared to 2010. Moreover, it is highlighted that the cost of piracy to the global economy is approximately $12 billion annually. As of today, Somali pirates hold 23 ships with 439 crew hostage. It is known that pirates demand a ransom of millions of dollars to release the ships and crew.

It is recommended that trade ships travel in military convoys during their passage through the danger area to prevent the threat and acts of piracy carried out in a very huge geography.

Illegal immigration, human trafficking, and smuggling are other important issues that shape security strategies, constitute a threat and require precautions. These are major problems of our age especially faced by the developed countries and transit countries in the international arena.

In general terms, migration, a phenomenon as old as human history, is the movement of individuals or communities from one settlement to another, from one city to another, from one country to another, and also from one continent to another for economic, social or political reasons. In more scientific terms, migration is the movement of individuals or groups from one to another place to settle permanently or temporarily with a motivation to obtain better conditions of education, health, and employment. (Şen, 2006)

Illegal immigration is not a problem faced only by a number of countries in a regional context; it is a common issue encountered by almost all the world countries. The reasons for this act carried out contrary to legal rules are generally the same across the world. These have generally been identified and classified by the Turkish Police Organization as follows: the conflict of interest between countries, regional wars, internal wars, economic difficulties, political and ethnical pressures, famine and scarcity, epidemics, the desire of human masses affected by the income gap between countries for a more comfortable and better life, family problems, and regional and cultural differences in the country.

Migrant trafficking and smuggling, one of the crimes committed by establishing an illegal organization to derive an improper personal profit, has increasingly become a major problem across the world. The appeal of easy money made from trafficking when compared to other forms of crime increases the frequency of such type of crime and leads to the establishment of organized cartels and organized groups in a global context.

Such organized groups carry out a major part of their operations related to human and goods trafficking by illegal means over seas and waterways. It is necessary to develop security strategies in this regard at the national and international level.

2.2 Maritime Security for Turkey

Turkish straits, one of the most important waterways in the world with no alternative, are internal waters of Turkey and Turkey also has control over the Suez Canal with many important waterways. Any threat of terrorism in such a geography, whether aimed at Turkey or not, will have a direct effect on the security and economy of Turkey.

Today, commercial maritime transport is much more freely and safely carried out all across the world when compared to road and air transport. Any interruption of maritime transport for some reason or failure to maintain its security may cause great damages 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.

"8 of 9 vital waterways among the most important 18 waterways in the world pass through the Mediterranean." (Davutoğlu, 2002) The blockage of the relevant 8 waterways in some way will severely hamper the world maritime trade and oil transportation.

Maritime transport is the most preferred mode of transportation due to its easy accessibility, its being the safest mode of transportation, its high capacity, and its cheapness thanks to these advantages.

Turkey is located in the Mediterranean basin, at the junction point of the East-West, North-South axes, and at the hub of transport links from Europe to the Atlantic, Arabian Peninsula, Middle East and Far East. Thanks to this geographical advantage of Turkey with a coastline of 4500 nautical mile (8333 km), the maritime transport will be available in all regions of the country. Maritime transport accounts for 90% of the world's maritime trade volume and 85% of Turkey's foreign trade volume. (TCS, 2010)

Furthermore, Turkey is surrounded by the Black Sea, the Mediterranean, the Sea of Marmara and the Aegean Sea, each with different ecological characteristics. The Sea of Marmara is an inland sea; the Black Sea coastline is 1.700 km in length, the Aegean Sea 2.805 km (excluding the islands), and the Mediterranean 1.577 km. Approximately 70 percent of Turkey's population live in coastal areas. Turkey's being the junction of three continents and its closeness to the markets of Russia, European Union and Middle East encourage the use of sea routes for commercial purposes. Due to increasing energy requirements of the world, the maritime border security of Turkey, located on the transition route of energy corridors of Russia, Central Asia and Middle East, which are energy supplying regions for the USA and European Union – energy consuming countries - becomes an important issue for all countries in the region.

When explaining the security concept for Turkey, it is necessary to describe the concept of exclusive economic zone. Besides its internal and territorial waters, Turkey has the right to use an area called as the exclusive economic zone starting at the seaward edge of its territorial sea and extending outward, whether underneath the sea-bed or over the water surface, up to a distance of 200 nautical miles from the coastal baseline as per the provisions accepted on November 10, 1982, at the third Conference on the Law of the Sea. Thanks to the Exclusive Economic Zone, the coastal state obtains many rights over the related area. The state which declares a stretch of water an exclusive economic zone then gains sovereign rights relating to the exploration, exploitation, conservation and management of natural resources, whether living or non-living, of the waters superjacent to the sea-bed and of the sea-bed and its subsoil. Moreover, the coastal state has exclusive jurisdiction with regard to the establishment and use of artificial islands, installations and structures; marine scientific research; the protection and preservation of the marine environment; and customs, fiscal, health, safety and immigration laws and regulations.

Figure 2.1 Exclusive economic zone map of Turkey

Figure 2.1 shows the exclusive economic zones of Turkey in the Black Sea and Mediterranean. As the Aegean Sea is not an open sea, it cannot claim for the right of an exclusive economic zone.

It may be helpful to review maritime trade volume of Turkey to get a better understanding of maritime security for Turkey.

Based on data from the Turkish Statistical Institute, it can be concluded that maritime transport, road transport, rail transport, other means of transport (postal consignment, fixed transport installation, self-propelled vehicles), and air transport account for 85%, 12.6%, 0.8%, and 0.8%, respectively, of the foreign trade volume of Turkey.

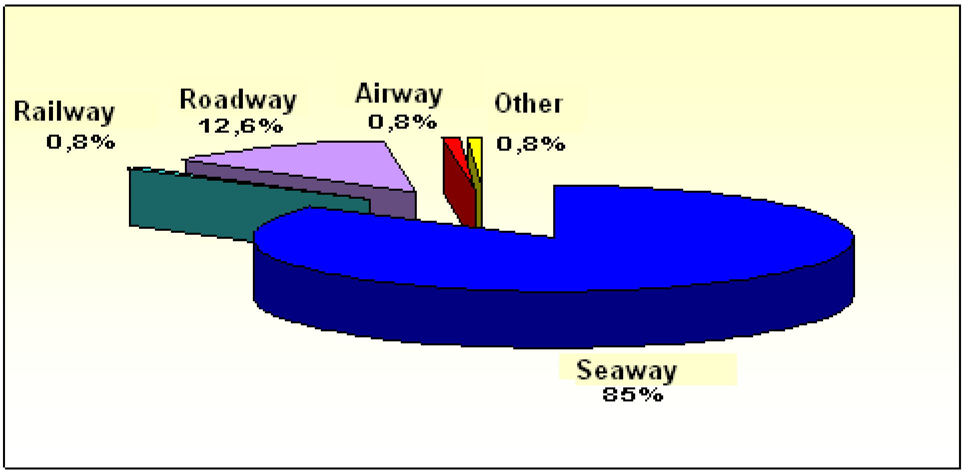

Figure 2.2 Foreign trade transportation by modes (TCS, 2010)

Furthermore, the steady demand for maritime transport causes intense competition in many fields such as shipbuilding industry, ship ownership and ship management, port management and logistic services, which make up the maritime sector. This necessitates certain activities such as flag state and port state applications with regard to safe maritime navigation as a natural result of maritime activities requiring a dynamic structure whose standards are directly dependent on international rules and technological developments.

As per the Turkish Cabotage Law, the term “cabotage” or “coastal shipping” refers to maritime transports carried out by Turkish ships between the ports or docks of Turkey. In Turkey, the coastal shipping data includes cargo, passenger and vehicle transports. Coastal shipping data is the most important indication of the course of economy.

According to data from the Turkish Chamber of Shipping, a 22.6% increase was recorded in coastal shipping between 2004 and 2009. Coastal shipping is distributed by regions as follows: Marmara Region 54%, Black Sea Region 11%, Mediterranean Region 16% and Aegean Region 19%.

When the export and import transports of Turkey are evaluated based on data from the Turkish Statistical Institute, it can be indicated that the major segments of the exports in 2009, amounting to a total of 73.7 million tons, include iron and steel industry (20.9%), cement, lime and gypsum (18.5%) and refined oil products (6.2%).

According to data from the Turkish Statistical Institute, Iraq stands 1st with 8.4 million tons, Italy stands 2nd with 6.4 million tons, and Egypt stands 3rd with 5.4 million tons on a quantity basis and also Germany stands 1st with $9.8 billion, France stands 2nd with $6.2 billion, and United Kingdom stands 3rd with $5.9 billion on a value basis in the ranking of top exporting countries in 2009.

According to data from the Turkish Statistical Institute, Russia stands 1st with 35.0 million tons, USA stands 2nd with 11.5 million tons, and Ukraine stands 3rd with 10.4 million tons on a quantity basis and also Russia stands 1st with $19.7 billion, Germany stands 2nd with $14.0 billion, and Chine stands 3rd with $12.2 billion on a value basis in the ranking of top importing countries in 2009.

As understood from the above-given figures, Turkey is a country which has caught and maintains the growth trend and depends on the sea for 85% of its trade activities, and thus it should develop strategic plans related to the use of maritime trade routes of great importance for Turkey itself and maintain their security. This is a must not only for the self-interests of Turkey, but also for the interests of other countries.

2.3 Maritime Policies and Turkey's Contributions

Any problem at sea routes, representing the common interests with regard to the world economy, has an effect even on the countries on the other side of the world. Especially, the recent acts of piracy and hijacking in the Gulf of Aden and Cape of Africa are the most concrete evidence of this effect. Even the hijacking of several ships passing through this zone has rigged the economy and caused fluctuations in oil prices and these acts have come to the world's agenda.

In this context, the countries have established collaborations, without delay, in high seas where the acts of piracy occur, and cooperated with other states, especially NATO members, located at a close distance to the related zone and having interests in this regard.

Furthermore, the Combined Maritime Forces (CMF) established Combined Task Force 151 (CTF-151) specifically for counter-piracy operations in the Gulf of Aden. CTF 151 operates in the Gulf of Aden and off the eastern coast of Somalia covering an area of approximately 1.1 million square miles. CTF-151 is a multinational task force established in January 2009 to conduct counter-piracy operations to actively deter, disrupt and suppress piracy in order to protect global maritime security and safe and free navigation for the benefit of all nations. CTF 151 includes naval forces from the USA, Korea, Singapore and Turkey.

In addition, EU Maritime Policies which will be handled by Turkey during the candidacy period of the EU accession negotiation process are one of the issues to be addressed in this context.

In a meeting held in 2008, the European Council of Ministers of Transport expressed their views on the communiqués regarding the "EU Maritime Transport

Strategy until 2018" and "Action Plan with a view to establishing a European Maritime Transport Space without barriers”.

The commission established by this council put forward six proposals related to strategic areas of activity. These areas include: European Shipping and Globalization, International Cooperation, Short Distance Maritime Transport, Freight and Passenger Transport in Europe, as well as Research and Development. The European Ministers of Transport called on the Commission to protect or improve the European framework legislation on state aids, tonnage and income taxes and also pointed to the necessity of taking supplementary measures to improve the image of shipping and introduce various maritime jobs.

The Council put emphasis on the importance of Short Distance Maritime Transport for the EU internal market compared to other modes of transportation. Moreover, a request was made to simplify the administrative procedures for transports between the European ports. The EU Integrated Maritime Policy concentrates on the following aspects with a view to maximize the sustainable use of seas:

- Providing maritime transport in Europe without barriers
- Improving port operations which constitute a ring of the logistic chain
- Improving the quality of marine environment
- Reducing ship emissions which cause air pollution
- Using innovative and environmentally friendly technologies in vessels and for shipbuilding and repair
- Environmentally friendly ship dismantling
- Motorways of the sea
- Installing Border and Maritime Surveillance Systems
- Regulating fishery activities, bottom sweep and preventing illegal fishing
- Maritime training
- Research & Development and innovation activities

When viewed from the aspect of maritime sector, Turkey-EU relations show an increased improvement in the harmonization process due to Turkey's being party to important international conventions by giving approval before most countries. (TCS, 2010)

Today, there are many projects in operation across the world with regard to illegal immigration which is one of the major issues of transit and developed countries and these projects vary regionally or according to geographical conditions. For the American continent and the United States of America, satellite tracking systems and long-wave (HF) radars are used against intruders from Mexican and ocean boundaries in order to prevent illegal immigration attempts. However, it is more useful and common for the EU member states to use microwave radars and provide coast guard patrols along the maritime boundaries. Likewise, as one of the security policies, readmission agreements are signed for the EU region. Readmission agreements aim to send back immigrants, illegally infiltrating the EU borders from the signatory countries or those whose asylum requests is rejected, to their country of origin or legal residence. Negotiations are required to make readmission agreements between the EU and source, target, and transit countries. If readmission agreements are first signed with the EU countries, regarded as target countries, before making such agreements with source countries, difficulties will be faced in returning illegal immigrants to their countries of origin or transit countries and problems will arise in providing accommodation and food. Therefore, such agreements should first be made with source countries.

According to data from the Ministry of Internal Affairs, Turkey proposed draft readmission agreements to Iran, Pakistan, Bangladesh, Afghanistan, India, Syria, China, and Sri Lanka, as source countries, and to Bulgaria, Greece and Romania, as transit countries, in early 2001.

On the other hand, Turkey proposed draft readmission agreements to Jordan, Russian Fed., Tunisia, Uzbekistan, Mongolia, Egypt, Kyrgyzstan, Israel, Georgia, Ethiopia, Sudan, Algeria, Libya, Morocco, Lebanon, Nigeria and Kazakhstan in April and May, 2002.

A readmission protocol predicting the readmission of domestic citizens and third country citizens entered into force after having been signed by Turkey and Greece, as transit countries.

- As a result of bilateral negotiations, a readmission agreement was signed between Turkey and Syria on September 10, 2001;
- A readmission protocol was signed between Turkey and Greece on November 8, 2001. The protocol entered into force after having been ratified by the parliaments of both nations.
- Negotiations are in progress with Bulgaria and Romania.
- Due to the existing political structure of Iraq and Afghanistan, no progress has been possible with these countries.
- Bangladesh declared not to be a signatory of this agreement.
- No answer has yet been received from other countries.

The projects drawn up by the Ministry of Internal Affairs to combat illegal immigration and trafficking more effectively are as follows:

- Project for Foreigner’s Admission and Repatriation Centers
- Project for the Modernization of Border Crossings
- Project for the Utilization of EU funds to Install Thermal Cameras on Turkish Coast Guard Boats
- Project for the Provision of Air Control Units for Coast Guard Forces to Detect and Prevent Migrant Trafficking in the Aegean and Mediterranean

2.4 Importance of the Security of the Aegean Sea and Outstanding International Issues

The Aegean Sea has sea routes of vital importance to the Aegean Sea itself and also to the states having a coast on the Black Sea. Due to its geographical structure, the Aegean Sea which is delimited by main lands to the east and west but connected with the Black Sea to the north and Mediterranean to the south, is of importance to the states having a coast on the Black Sea and also to the states having maritime trade relations. On the other hand, the importance of the Aegean Sea for Turkey is based on the aspects of sovereignty, military, politics and economy due to disputes between Turkey and Greece.

The Aegean Sea accounts for a large portion of the foreign trade volume of Turkey. In addition to this, it serves as a terminal in external connections of the most industrialized regions of Turkey such as Istanbul, Kocaeli, Bursa and Izmir.

Currently, there is a lack of alternative port facilities and industrial plants in the Mediterranean. Therefore, if inbound and outbound vessel traffic is blocked, import and export will be paralyzed, great difficulties will be experienced in the energy industry in parallel with a decline in fuel oil production, and an energy crisis will be faced in the industry.

The Aegean Sea, with a coastline of 3484 km excluding specific geographical formations such as islands, islets and rocks whose sovereignty has not been transferred by agreements, is also of great importance with regard to tourism, fishery, sponge and historical artifacts at the bottom of the sea.

The Aegean Sea is of vital importance to Turkey and Greece with regard to defense. However, the Aegean Sea cannot only be assessed from the aspect of defense. It accounts for a large portion of exports and imports and raw material and fuel oil inputs of both Turkey and Greece and also the countries having a coast in the Black Sea. (Ayyıldız, 2007)

The Aegean Sea accounts for 85% of the foreign trade volume of Turkey. 75% of trade between the Aegean, Marmara and Black Sea ports is conducted through the Aegean Sea. High energy requirements resulting from the industrialization can substantially be satisfied by oil import. This external reserve should be maintained continually for the proper functioning of economy. 75% of oil import is conducted through the Aegean Sea. Two of the oil refineries of Turkey (İzmit İPRAŞ and İzmir TÜPRAŞ) can only be accessed via the Aegean Sea.

Likewise, Greece depends on the Aegean Sea for a large portion of its foreign trade activities and for the transports between its mainland and islands due to its having one of the special merchant navies of the world and its culture being closely connected with the sea and shipping.

This clearly shows the vital importance of the Aegean Sea for both Turkey and Greece. The Aegean Sea is not only a vital waterway for Turkey and Greece, but also for many states, especially Russia. The users of the Aegean Sea are comprised mostly of the countries having a coast in the Black Sea or those having maritime trade relations, which reveals the importance of the Aegean Sea to the international platform. (Ayyıldız, 2007)

Fishery activities are extensive in the Aegean, especially the North Aegean, as the Mediterranean has high salinity and thus limited favorable habitats for fishes. The hatcheries having been built in Turkey and Greece in recent years have also lead to a considerable increase in economic inputs in this industry.

According to data from the Undersecretaries for Maritime Affairs, a total of 103.795 ships passed through the Bosphorus and the Dardanelles in 2006. 54.880 ships with a total weight of 475.796.880 tons passed through the Bosphorus in 2006. 10.153 of the passing ships carried d a total of 143.452.401 tons of dangerous cargo.

48.915 ships with a total weight of 595.826.240 tons passed through the Dardanelles in 2006. 9.567 of the passing ships carried a total of 143.452.401 tons of dangerous cargo.

The Aegean Sea is a region which should be protected due to its importance. For Turkey, which is in a prolonged fight and combat against the separatist terrorist organizations, the disagreements with Greece over the Aegean Sea constitute a critical risk for national and regional security.

2.5 Aegean Issues

There are many outstanding disputes between Turkey and Greece over the Aegean Sea, which negatively affect both the economic and political coordination and collaboration between two countries. As for the nature and cause of disputes, it can be said that the Greek desire of sovereignty over the Aegean Sea and Thrace and Aegean Islands stands out as the underlying reason escalating into an unsolvable issue because Turkey is late to show necessary political reactions. The settlement of the Aegean issues, irrespective of their origin, by peaceful and reasonable means, will make considerable contribution to the economies of both countries and facilitate to maintain security in the Aegean Sea. It may be helpful to review the outstanding issues in detail before proceeding to the security aspect.

2.5.1 The Breadth of Territorial Waters

Territorial waters are a part of the territory and maritime boundary of a coastal state where the rights and powers of sovereignty are exercised. Any change in the boundaries of the Aegean territorial waters negatively affects the rights and interests of Turkey over the Aegean Sea.

Turkish and Greek territorial waters were limited to 3 nautical miles in 1923 by the Treaty of Lausanne. However, in 1936, Greece unilaterally extended its territorial sea to 6 nautical miles. The initial dispute between Greece and Turkey over the breadth of the territorial sea in the Aegean Sea arose in 1964 when Turkey also decided to extend its territorial sea to 6 nautical miles. (Ayyıldız, 2007)

The dispute between two countries over the breadth of the territorial waters reached serious dimensions due to the desire of Greece to turn the Aegean into a Greek lake by extending its territorial waters in the Aegean Sea beyond 6 nautical miles.

Greece maintained the traditional territorial sea breadth of 3 nautical miles in the Aegean Sea until 1936. The Law No. 230 of 17 September 1936 on the breadth of the territorial waters of Greece fixed the breadth of Greek territorial waters at 6 nautical miles from the coast. By this law, Greece had 42% of the maritime area of the Aegean Sea. (Ayyıldız, 2007)

The Treaty of Lausanne does not include a final judgment regarding the Turkish territorial waters. Nevertheless, Turkey agreed to limit its territorial waters to 3 nautical miles based on Article 6 and 12 (The islands with a distance of less than 3 miles from the Asian coast shall remain under Turkish sovereignty) of the Treaty of Lausanne. Later in 1964, Turkey also extended its territorial waters to 6 nautical miles. However, this does not mean a waiver of its rights, in favor of other states, over the waters outside the limits of the Turkish territorial waters in the Aegean Sea.

The Third UN Convention on the Law of the Sea (UNCLOS-III) granted every coastal state the right to extend its territorial waters up to 12 nautical miles, and also it gave rocks and islands with no human inhabitants the right to a territorial sea and granted every island the right to have a territorial sea, contiguous zone, exclusive economic zone and continental shelf (see Figure 2.3). Thus, Turkey did not become a signatory of this convention.

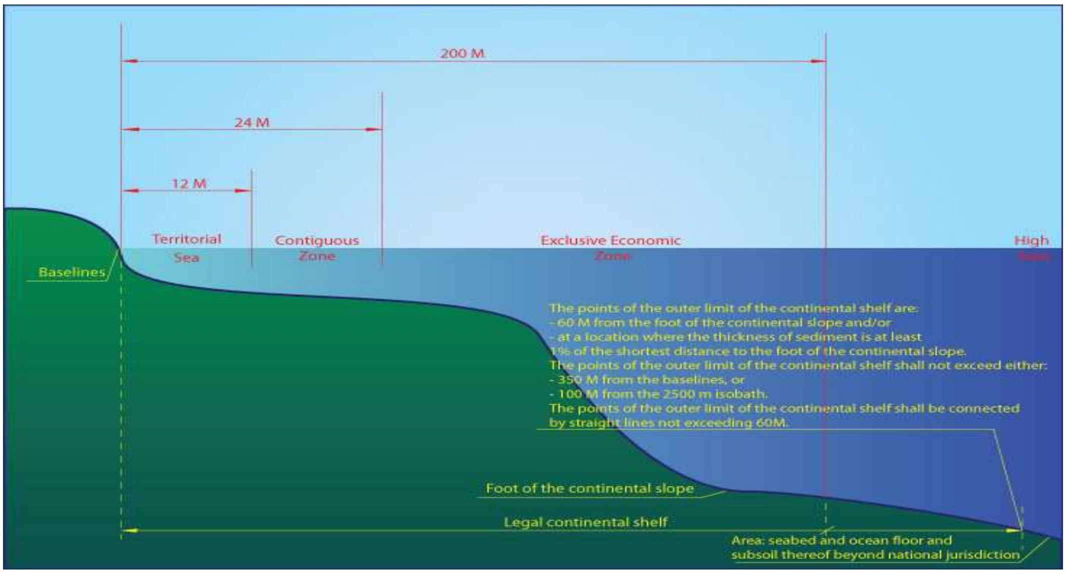

Figure 2.3 Claimed maritime zones determined by the United Nations (http://www.un.org/depts/los/clcs_new/marinezones.jpg)

The Aegean Sea is a semi-closed sea surrounded by the coasts of Turkey and Greece. It is a very special sea with numerous islands due to its geographical and geological characteristics. This is why the issue of the breadth of the territorial waters is one of the most complex and controversial issues of the international maritime law. The international agreements signed by Turkey and Greece determine the legal status of the Aegean Sea.

Assuming that all islands, islets and rocks (excluding Imbros, Tenedos and Rabbit Islands) located at least 3 miles from the Anatolia are allegedly under the Greek jurisdiction, and under the present 6-mile limit for the breadth of the territorial waters, the Greek territorial sea makes up approximately 43.68% of the Aegean Sea, while Turkish territorial sea represents only 7.5%. The remaining 49% of the Aegean has the status of high seas. Figure 2.4 shows a map where the Greek territorial sea is limited to 6 nautical miles. As shown in Figure 2.5, in the case of 12-mile limit bilaterally, Greece would have sovereignty over more than 71% of the Aegean with a significant increase of 28%, compared to 1% increase in favor of Turkey. The portion of high seas will fall below 20%. Table 2.1 shows the aforementioned two cases.

Table 2.1 Distribution of the Territorial Waters and International Waters by the Breadth of the Territorial Waters (Bölükbaşı, 2004)

<table>
<tr><th>Breadth</th><th>Turkish Territorial Sea (%)</th><th>Greek Territorial Sea (%)</th><th>High Seas (%)</th><th>ASR</th></tr>
<tr><td>6 nautical miles</td><td>7.47</td><td>43.68</td><td>48.85</td><td rowspan="2">Approximately 4.5%</td></tr>
<tr><td>12 nautical miles</td><td>8.76</td><td>71.53</td><td>19.71</td></tr>
</table>

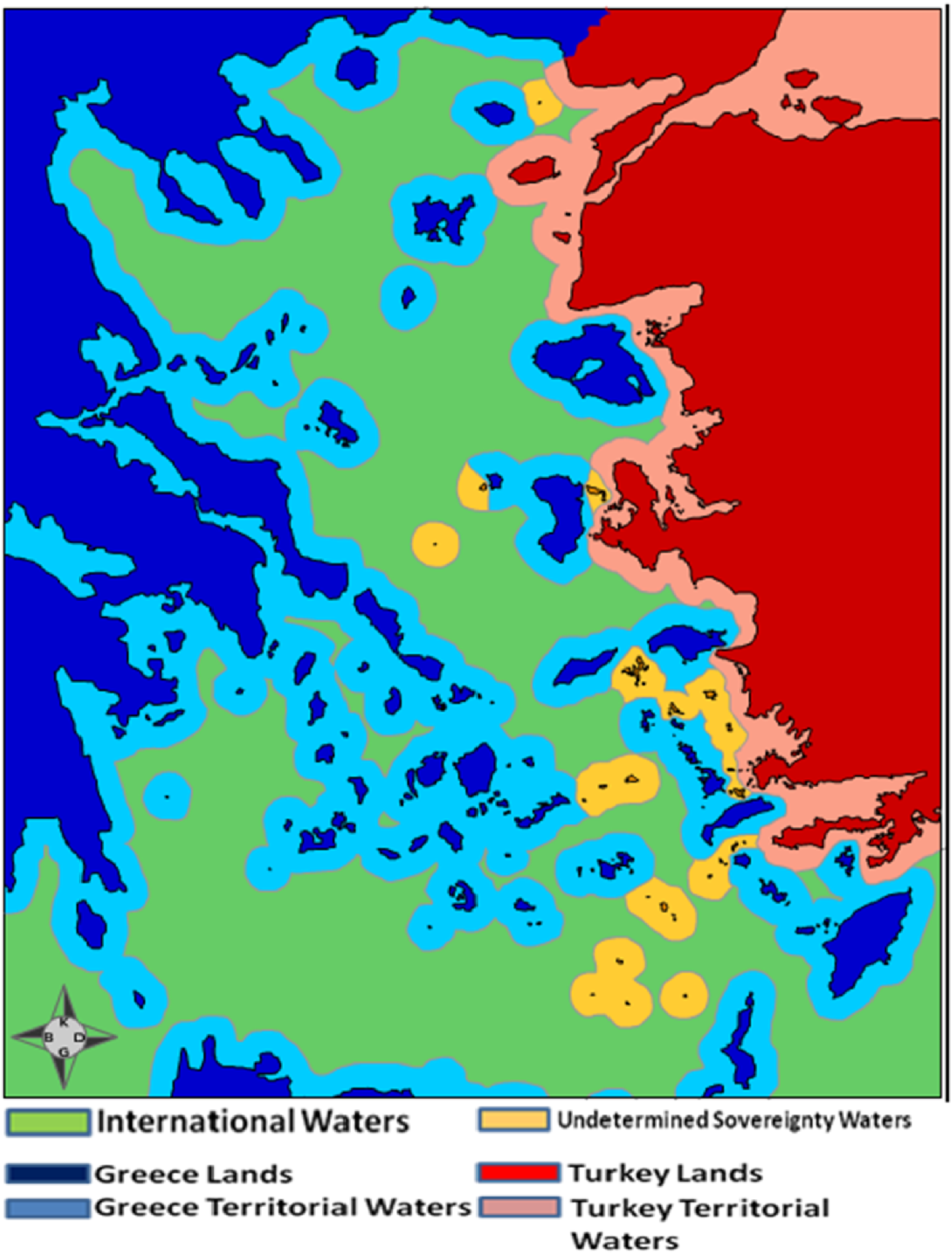

Figure 2.4 The current case of 6-mile limit for the Greek territorial waters in the Aegean Sea (6 Miles Territorial Waters, nd, http://www.casusbelli.org/haritalar/haritalar/har1.html)

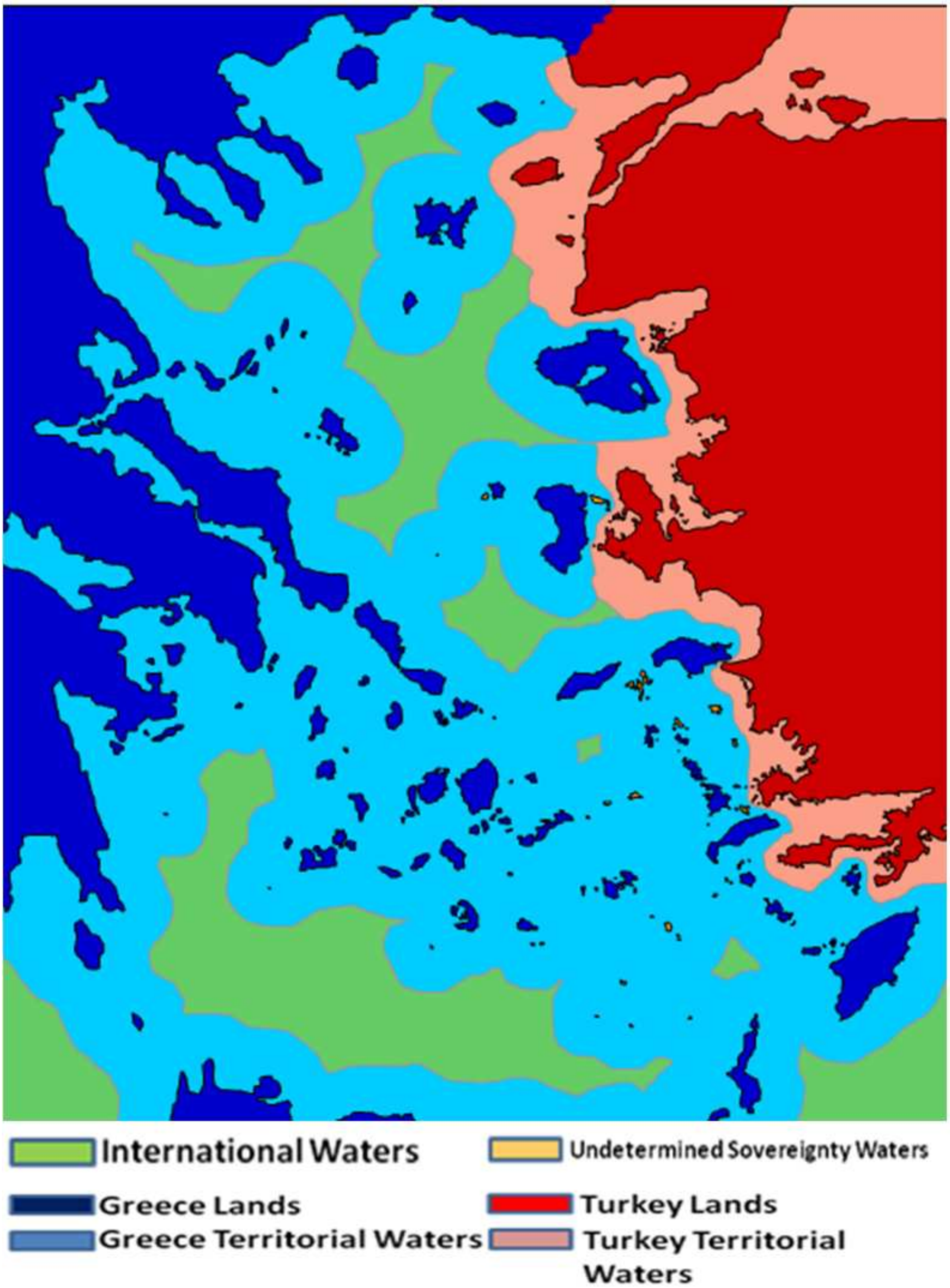

Figure 2.5 The case of 12-mile limit for the Greek territorial waters in the Aegean Sea (6 Miles Territorial Waters, nd, http://www.casusbelli.org/haritalar/haritalar/har1.html)

The issue of the breadth of the territorial waters has been alleviated before escalating further when Turkey declared that any unilateral extension of the Greek territorial waters to 12 nautical miles would constitute a casus belli (a cause of war).

2.5.2 The Delimitation of the Continental Shelf

The concept of continental shelf is a technical term used by geographers and geologists. It is essentially is a geographical, geological and oceanographic concept. It is a term used to express the natural undersea extension of the national territory of coastal states (Kocaoğlu, 1993). According to the investigations, the seabed slowly deepens up to 155- fathom isobaths from the coast and its depth suddenly increases after 100-fathom isobaths. This area is called "the continental shelf" by geologists and geographers. (Çelik, 1982)

In other words, "Coasts are not the borders of continents. Continents extend underwater to a certain point. The gently sloping (0 degrees 0.7 minutes) submerged plains and terraces along the shallow continental margin are called "the continental shelf." (Önder, 2008)

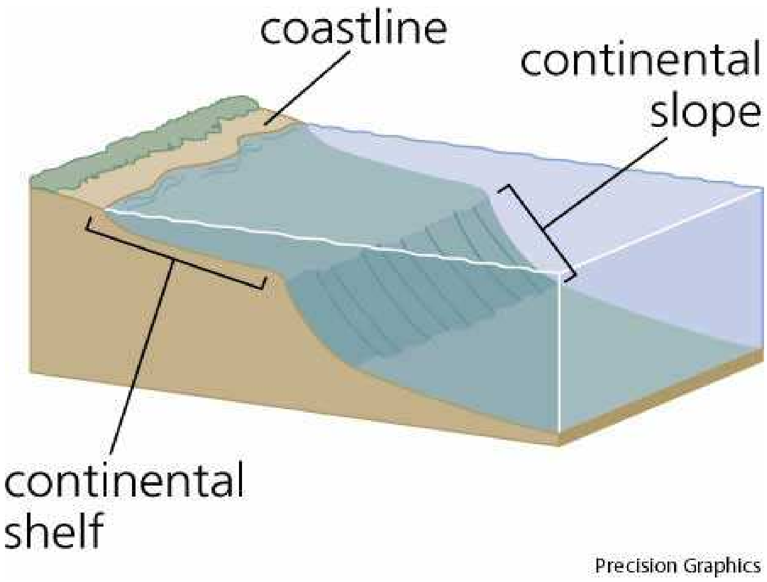

Figure 2.5 Continental shelf (Continental Shelf, nd, http://images.yourdictionary.com/images/main/A4cntshf.jpg)

As understood from Figure 2.5 and the above mentioned information, the continental shelf is the undersea extension of a mainland and constitutes the prolongation of the relevant coastal state.

The dispute between Turkey and Greece over the delimitation of the continental shelf arose when the Turkish government granted an exploration license to TPAO (National Petroleum Company of Turkey) for oil explorations in the Aegean high seas and in 27 zones within the continental shelf of Turkey and then this exploration license was published, with a map showing the limits of continental shelf rights of Turkey, on November 1, 1973. This area is located between the Aegean islands of Samothrace, Limnos, Lesbos, Agios, and Chios, and situated off the territorial waters of these islands.

On 7 February 1974, the Greek government sent a diplomatic note to the Turkish government stating that the exploration license granted by Turkey is not valid on the grounds that the areas covered in the license are within the Greek Continental Shelf. The Turkish government replied on February 27 by a diplomatic note stating that the territories extending underwater from the Anatolian Coasts to the west are the natural prolongation of the Anatolian landmass, thus constituting the continental shelf of Turkey, and that the islands close to the Turkish coasts are within the Turkish Continental Shelf and do not posses their own area of continental shelf. (Ayyıldız, 2007)

Greece based its argument on the provisions of the Geneva Convention on the Continental Shelf of 29 April 1958. However, Turkey did not sign this convention and thus considered it as non-binding and proposed to resolve the dispute over the delimitation of the Aegean continental shelf by negotiations pursuant to the rules of law, namely to set the limits of the Aegean continental shelf by compromise.

The dispute between Turkey and Greece over the delimitation of the continental shelf also continued in 1975. Greece insisted on submitting the dispute to the International Court of Justice, whereas Turkey preferred to reach a settlement by negotiations. During negotiations between the Turkish and Greek Ministries of Foreign Affairs in Rome on 19 May 1975 and between the Turkish and Greek Prime Ministers in Brussels on 31 May 1975, an “agreement in principle” was reached in order to submit the dispute to the International Court of Justice. However, the parties did not come to a conclusion in the meeting held to issue an application.

A further cause of tension arose in 1976 when Turkey dispatched a research ship, *Hora* (also known as *Sismik-I),* for seismological explorations in order to prove its determination in protecting its continental shelf rights in the Aegean Sea. In response, Greece made several attempts towards Turkey to prevent the sailing of *Hora* into the Aegean Sea and declared that *Hora* would cause a “dangerous situation” between Turkey and Greece should it enter the “Greek Continental Shelf”. Turkey declared that it would respond harshly in case of any attack to *Hora*. (Ayyıldız, 2007)

On 6 August 1976, *Hora*, set sail from the Dardanelles, escorted by warships, into the disputed waters. The Greek warships tracked *Hora* continuously. *Hora* returned back to the Dardanelles on 10 August 1976 after the completion of explorations.

In response, Greece took two actions. Firstly, it appealed to the UN Security Council and argued that Turkey perilously threatened peace and security by breaching the continental shelf rights of Greece in the Aegean Sea. At the end of negotiations on August 12, the Security Council adopted a resolution calling on the two governments to strive to exercise restraint and reduce tensions in the area and seek a solution through negotiations. , resume direct negotiations and appealed to them to do everything within their power to reach mutually acceptable solutions.

Secondly, Greece submitted the dispute to the International Court of Justice (ICJ) on 10 August 1976 and requested the Court to prevent the actions of Turkey with *Hora* on the grounds that the entrance of *Hora* into the Greek Continental Shelf caused “irreparable damage”. However, the Court rejected the request of Greece based on the fact that Hora did not cause irreparable damage. The Court eventually decided in January 1979 that it lacked the jurisdiction to rule in the Aegean Sea Continental Shelf case and thus rejected the application of Greece. (Ayyıldız, 2007)

After the call of the UN Security Council, the authorized persons of both parties held a meeting in Bern (Switzerland) on 11 November 1976. They signed a document consisting of 10 articles called the Bern Declaration which was officially released in both Ankara and Athens on 20 November 1976.

The Berne Declaration covers the procedures to be followed by both parties during the negotiations for the delimitation of the continental shelf. Within the framework of this declaration, both parties agreed that negotiations would be sincere, detailed, conducted in good faith, and kept strictly confidential and no statements or leaks to the press would be made referring to the content of the negotiations. Also, both parties undertook, as far as bilateral relations are concerned, to abstain from any initiative or act which would tend to discredit the other party. (Toluner, 1989)

In this way, a moratorium was placed on the activities related to the continental shelf until the dispute over the Aegean Sea Continental Shelf is settled and this moratorium has been maintained to the present day. (Kuramahmut, 1998)

It is an established rule of the international law that the rights of the coastal state over its continental shelf exist *ipso facto* and *ab initio*, as explained in the Article 4 of the Convention on the Continental Shelf adopted at the 1958 Geneva Conference on the Law of the Sea, stating: "Subject to this, the coastal state exercises its right to carry out explorations on its continental shelf and exploit its natural resources."

Although some of the Greek islands in the Aegean Sea are within the natural prolongation of the Turkish mainland, Greece claims for full sovereignty over the Aegean sea beds on the grounds that that these islands allegedly have their own area of continental shelf, which is the major cause of disputes.

The limits of the continental shelf between the coastal states are set by various regulations and agreements. Turkey wishes to resolve the ongoing dispute with Greece over the continental shelf by negotiations pursuant to equal sharing of the Aegean Sea.

On the other hand, Greece considers the Aegean as a Greek lake and thus regards the Aegean continental shelf dispute only as the delimitation of the continental shelf between the Anatolia and North Aegean Islands. Greece insists on appealing to the International Court of Justice to resolve the ongoing dispute. (Ayyıldız, 2007)

For both countries, the delimitation of the Aegean continental shelf means sharing the Aegean Sea.

2.5.3 National Airspace

The 1944 Chicago Convention and international law limit the national airspace of a country to the breadth of its territorial waters.

In 1931, Greece claimed 10 nautical miles of national airspace by a decree, as opposed to 3 nautical miles of territorial waters. Furthermore, Greece established a control area around the island of Limnos, much of which is within the international airspace. On the other hand, Turkey has maintained 6 miles of national airspace since 1964 in compliance with the breadth of its territorial waters. (Ayyıldız, 2007)

Turkey has refused to acknowledge the validity of the outer 4-mile belt of airspace extending beyond the Greek territorial waters and attested that the control area arbitrarily established around the island of Limnos violates the International Airspace, which has caused the current issue of the Aegean airspace. Turkey has repeatedly declared to Greece that it does not recognize airspaces established arbitrarily by Greece.

Greece claims 10 nautical miles of airspace, as opposed to currently 6 miles of territorial waters. Accordingly, the aircrafts entering the 10-mile zone would allegedly violate the Greek airspace. However, Turkey does not recognize the unlawful claim of Greece for 10 nautical miles of airspace which is contrary to the provisions of international law and the Chicago Convention of 1944. Greece arbitrarily bases its claim on a decree dated 1931 and such a groundless claim is put forward only by Greece in the world.

The aforementioned decree was declared in 1974 in the Aeronautical Information Publication of Greece and Turkey immediately objected to this. (Kurumahmut, 1998)

Greece, based on its claim of a 10-mile airspace, alleges that Turkish military aircrafts violate the Greek airspace during both training flights and exercises.

On the other hand, Turkey decidedly objects to any claim of a 10-mile airspace and continues to use the airspace beyond the 6-mile Greek airspace during international activities, military exercises and training activities. (Çoban, 2007)

2.5.4 The Delimitation of the Flight Information Regions

Flight Information Region (FIR) is a zone assigned by the International Civil Aviation Organization (ICAO) and providing flight information services. It does not grant the right of sovereignty to the state providing such services.

For flights over the sea, the NOTAMs (Notice to Airmen) in force apply to aircrafts flying in the international airspace between the FIR line and territorial waters. For controlled routes and airspaces, necessary permits should be taken from the relevant Air Traffic Control Units.

The present Istanbul-Athens FIR was included in regional plans in 1952 by the ICAO. When Greece attempted to designate the FIR line as its national boundary, Turkey made certain attempts before the ICAO in order to change this line in the years 1966, 1968, 1971 and 1974 consecutively, but no positive reply was received in this regard.

On 4 August 1974, during the Cyprus Peace Operation, Turkey issued NOTAM 714 requiring "all aircrafts approaching Turkish airspace to report their position and flight plan on reaching the Aegean median line, which lay to the west of the FIR line". Two days afterwards, Greece assumed NOTAM 714 as unacceptable as it violated the rules of ICAO. On 20 August 1974, with NOTAM 1066, Greece declared the Aegean airspace a danger area and prohibited flight of civil aircrafts within this area. (Ayyıldız, 2007)

On 29 February 1980, Turkey declared that it abolished NOTAM 714 and the Aegean airspace was opened to international air traffic.

FIR Line should not be treated as the Turkish-Greek boundary and should not limit the right of Turkey to equally and freely use the airspace over the high seas. International Civil Aviation Organization (ICAO) is a civilian organization, and in the Chicago Convention, it is clearly stated that only the aircrafts identified as civilian give flight information, and the regulations applicable to military aircrafts should be established by bilateral agreements. Since there is not a mutual agreement between Turkey and Greece on the subject, Turkey considers that it should not be obligatory for state aircrafts to be subject to the same implementations. (Kurumahmut, 1998)

The insistence on providing flight plan information for the flights to be conducted in the Aegean international airspace implies that the technical responsibility assumed by Greece in line with its FIR obligations may also be used as a means of air defense.

Although these approaches may support the allegations of Greece which considers the Athens FIR line as its sovereign airspace, Greece ignores that the Athens FIR line is not a political boundary and thus not required to be protected, and that the Chicago Convention does, in no way, cover an expression like "FIR lines are protected by the responsible country". It should also be noted that the identification of a NATO member as a threat by another NATO member is contrary to the objective and nature of NATO and thus brings peace in the Aegean Sea to a stalemate.

2.5.5 The Status of Islands, Islets and Rocks

The status of islands, islets and rocks (geographical formations) whose sovereignty has not been transferred to Greece by agreements is another chronic issue between Turkey and Greece.

On 25 December 1995, a Turkish cargo vessel *Figen Akad* ran aground near the Kardak rocks and this brought about a new dispute related to the title to certain insular features in the Aegean and the claims of sovereignty over the related rocks become formal between Turkey and Greece. (İnan & Başeren, 1997)

After this accidental event, Greece attempted to further expand its rights of sovereignty over the Aegean Sea transferred by international agreements and to capture all islands, islets and rocks beyond the 3-mile zone of the Anatolia and this has brought a new dimension to the Aegean disputes. (Kurumahmut, 1998)

The transfer of sovereignty should be performed by international agreements as clearly stated in the international law. The dispute over the geographical formations is related to the status of Aegean Islands whose sovereignty has not been transferred by agreements.

In this context, the transfer of a territory from one country to another is only possible by agreement, unilateral procedures or international arbitrations, or by decisions of judicial or organizational bodies. The case in the Aegean is the transfer of a territory from the Ottoman Empire / Republic of Turkey to Italy and Greece by agreements. (Ayyıldız, 2007)

The transfer of territory is the transfer of the rights of sovereignty of a state over a "limited territorial area" to another state by agreement. For the avoidance of doubt, transfer should be performed by an agreement which "explicitly reveals the wills of both parties in this regard" and "designates, identifies and describes the territory under transfer". This is because the sovereignty over a territory does not tolerate any hesitation. (Kurumahmut, 1998)

In order determine which of the Aegean Islands belong to Greece within the framework of the above mentioned rules, an attempt should first be made to determine which islands were transferred from the domination of Ottoman Empire/Republic of Turkey to Greece. For this purpose, the agreements which determine the legal status of the Aegean Islands should be reviewed.

As per the Article 15 of the Treaty of Lausanne, Turkey renounces, in favor of Italy, all rights and titles over the islands of Patmos, Lipsos, Leros, Kalimnos, Kos, Niros, Symi, Tilos, Calki, Rhodes, Karpathos, Kassos, and Astipalia as well as the "adjacent" islets and the island of Meis. By virtue of the provisions of the Article 14 of the Treaty of Paris, the sovereignty of the above mentioned 14 islands, including Meis, and also the "adjacent" islets was transferred to Greece. (Kurumahmut, 1998)

However, the aforementioned "adjacent islets" were concretely indicated neither in the text of agreement nor the attached maps. Therefore, the clarification of the criterion of being "adjacent" and the determination of the title to islands, islets and rocks in the Aegean have come up as an issue.

All islands, islets and rocks other than those stated in Article 15 of the Treaty of Lausanne are controversial. For example; Greece has no legal basis to justify its claims of sovereignty over the Kardak Rocks. Thus, Turkey does, in no way, renounce its rights over about 152 Aegean islands, islets and rocks whose sovereignty has not been transferred to Greece by agreements. (Ayyıldız, *2007)*

2.5.6 The Search and Rescue Area of Responsibility

Greece claims the west of the FIR line as the Greek Search and Rescue (SAR) area of responsibility. On the other hand, Turkey recognizes the SAR area whose exact location was declared to IMO in 1982. There is no mutual agreement signed by both countries in this regard.

Within the scope of the SAR regulation published in January 1989 in compliance with the provisions of the 1979 Hamburg Convention and the 1974 SOLAS (Safety of Life at Sea) Convention, Turkey holds that the SAR responsibility in the airspace over high seas does not cover maritime SAR activities in accordance with the rules of the International Civil Aviation Organization (ICAO). Turkey states that the regions to be provided with SAR services by Turkey itself beyond its territorial waters will be determined by agreements with the relevant states. Thus, Turkey declared to IMO the coordinates of high seas over which Turkey could provide SAR services beyond its territorial waters until the conclusion of an agreement. (Ayyıldız, 2007)

On the other hand, Greece declared to IMO in 1987 that it assumed the SAR responsibility on the west of the Athens FIR line in the Aegean Sea, and the disagreement on this subject still continues.

Greece ratified the Hamburg Convention in September 1989 and reserved the Article 2.1.4 of the Convention stating: "Each search and rescue region shall be established by agreement among the Parties concerned." and the Article 2.1.5 of the Convention stating: " In case agreement on the exact dimensions of a search and rescue region is not reached by the Parties concerned, those Parties shall use their best endeavors to reach agreement upon appropriate arrangements under which the equivalent overall coordination of search and rescue services is provided in the area." Greece wishes the SAR areas to coincide with FIRs. Turkey declared its readiness to negotiate the SAR boundaries for many times in the international platforms, whereas Greece does not agree to the determination of its SAR boundaries by agreement. (Ayyıldız, 2007)

CHAPTER THREE
ACTIVITIES FOR MONITORING MARINE TRAFFIC

3.1 Turkish Straits Vessel Traffic Services

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 Tanıtımı, nd, http://www.kegki.gov.tr/)

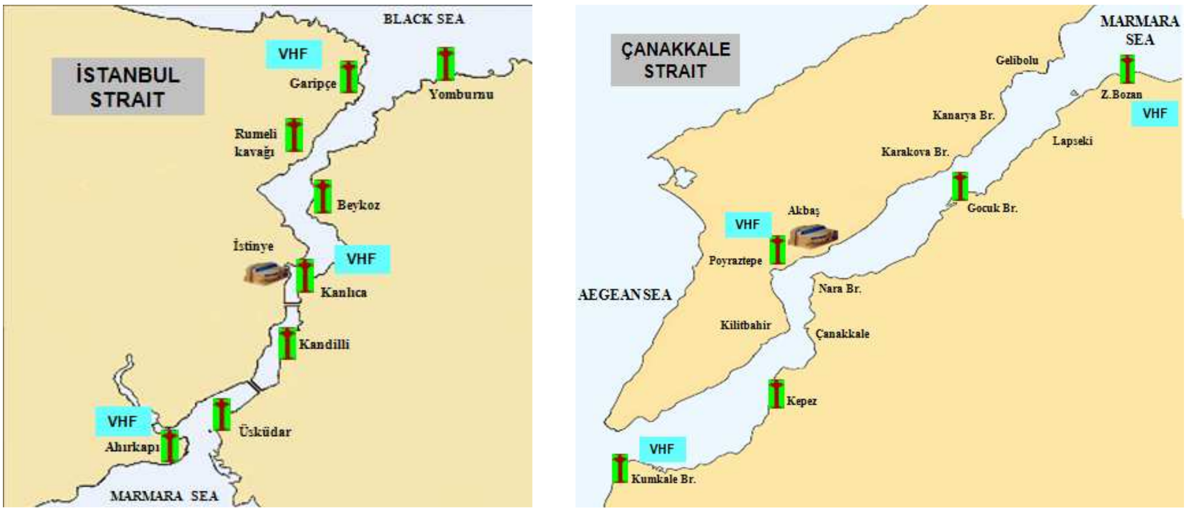

Figure 3.1 TSVTS and Traffic Monitoring Stations (TCS, 2010)

Turkish Straits Vessel Traffic Services (TSVTS) was commissioned on 30 December 2003 in order 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 2 July 2008 in order to monitor the vessel traffic running within the traffic separation scheme in the Sea of Marmara. With the integration of the Sea of Marmara into the main system, thus covering the whole area within the traffic separation scheme Marmara and 20-mile area located on the west and southwest of Tenedos (Bozcaada) (Figure 3.1), it is now possible to continuously monitor the vessel traffic from the Aegean Sea to the Black Sea. (TCS, 2010)

Figure 3.2 VTS Station (TBGTH Tanıtımı, nd, http://www.kegki.gov.tr/)

3.2 The Project for the Vessel Traffic Management System

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) in order 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 of dangerous cargos are handled, and passenger transportation is carried out. (TCS, 2010)

According to data from the Republic of Turkey Undersecretarian for Maritime Affairs, it is planned within the scope of the Project for the Vessel Traffic Management System that certain systems such as Turkish Straits Vessel Traffic Services, Automatic Identification System and Long Range Identification and Tracking System will be integrated and thus establishing a single-center vessel traffic management system. Moreover, works are in progress to install a management and information system called the Port Management Information System (PMIS) which will provide the management and monitoring of all information regarding the movements of and cargoes on Turkish or foreign flag ships.

3.3 Automatic Identification System

Automatic Identification System (AIS) an automatic tracking system used on ships for identifying and locating 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 not clear, the AIS requires a receiver or transponder to process the sound. (AIS Cihazları, nd, http://www.gemitrafik.com)

The vessels using 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 estimated time of arrival. AIS covers a shorter range compared to the radar systems used on ships, but provides much more detailed information.

As additional information, the Automatic Identification System (WAIS) is a type of AIS which is adapted to war ships. It is used by warships and submarines as well as the Coast Guard and Maritime Police. It uses a special encoding system and contains more detailed information than a standard AIS system. (Özdöl, 2011)

3.3.1 The Use of Automatic Identification System in Turkey

The AIS Center was commissioned on 9 July 2007 in order to improve the safety of navigation, protection of life, property and environment on Turkish coasts, reduce the risks of possible maritime accidents, and provide instant monitoring of marine traffic. (TCS, 2010) . As ships can be automatically interrogated via the AIS Base Stations installed on Turkish coasts, it is also possible to effectively control the ships navigating in the surrounding seas. Figure 3.3 shows the coverage of the structure built with AIS terminals.

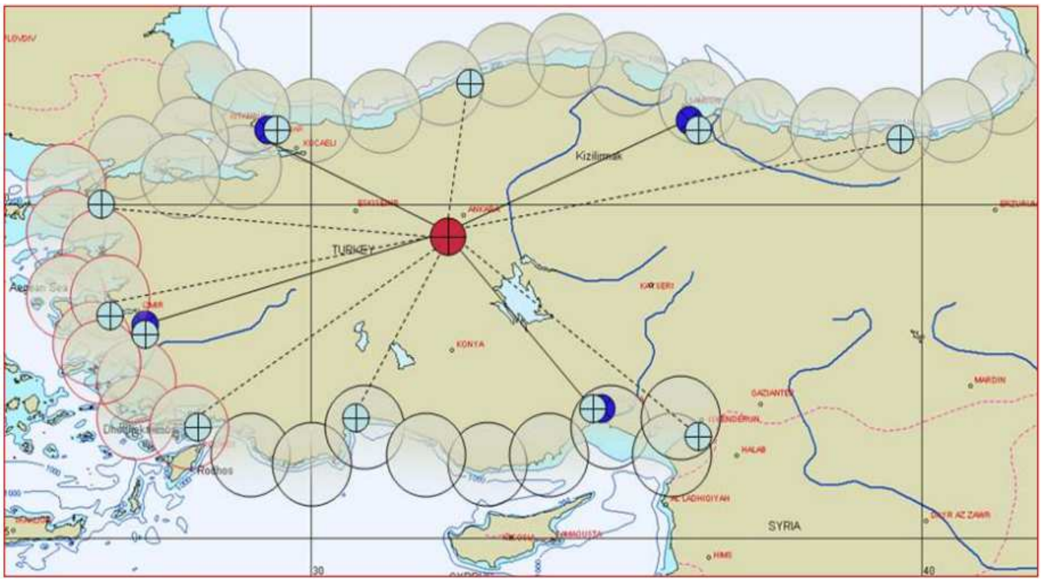

Figure 3.3 AIS terminals and their coverage (Kuloğlu, 2008)

In addition to its positive contribution to the safety of navigation, the AIS is also considered as the best technological solution under today's conditions to effectively monitor the coasts of Turkey with a coastline of longer than 8000 km within the framework of national and international obligations. The coverage of this structure is shown in nautical miles in Figure 3.4.

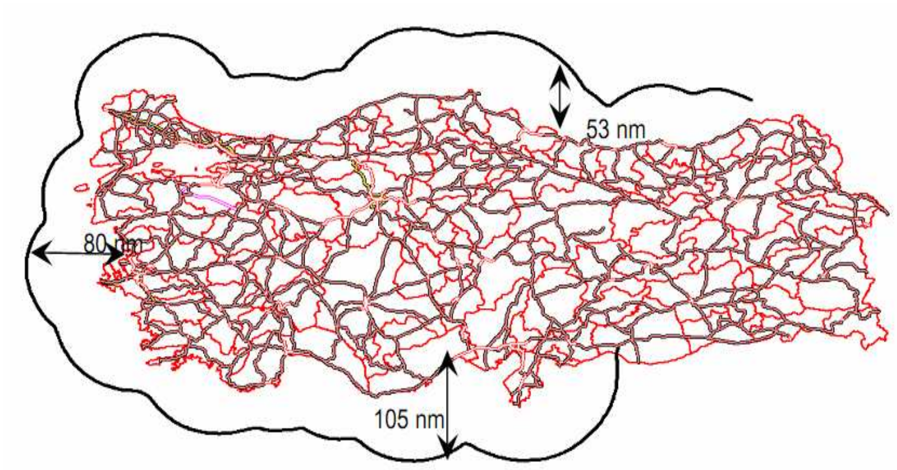

Figure 3.4 AIS coverage on Turkish coasts (Ayyıldız, 2007)

As a general architecture, the system consists of 4 main units: (TCS), 2010)

- AIS Base Stations: deployed on the coast and automatically collecting information from vessels.
- AIS Center: collecting, displaying and processing the information from all AIS Base Stations.
- AIS Ship Terminals: fitted on ships according to a certain schedule of operation.
- AIS User Centers: Institutions and organizations obtaining AIS information by being connected with the AIS Center.

The AIS Center collects information from the coastal base stations and then transfers it over the network infrastructure to the relevant institutions and organizations such as Turkish Naval Forces Command, Turkish Coast Guard Command, and Directorate General of Coastal Safety. In the AIS Center, all ships within the coverage of AIS base stations and having AIS terminals can be tracked almost in real time (with a delay of about 2-6 seconds) via the electronic chart display system and AIS software running on this system and digital maps. (TCS, 2010)

Table 3.1 lists the information sent by AIS terminals fitted on ships to coastal base and control stations and then transferred to the relevant institutions and organizations via coastal base stations.

Tablo 3.1 Information displayed by AIS (TCS, 2010)

Statics Information	**Dynamic Information**	**Information Related Cruise**
MMSI Number	Ships Position	Ship Draft
IMO Number	Time	Cargo Carried
Ship's and Calling Name	Route According to Position	Host Port and Harbor and Estimated Time of Arrival
Ship's Type	Speed According to Position	Start and Go to the Sailing harbor
Ship's Length and Width	Route Relative	Time of Ship's Navigation
Ship's Tonnage	Position (Cruise, Anchor)	Ship's Anchor Position and Aim
Ship's AIS Antenna Position	Rotate Rate	Others Information

One of the most important aspects of the AIS system is that it can urgently report any emergency situation (fire, conflict, accident, running aground, etc.) to coastal stations and thus enables such emergency situation to be responded in a very short time as the location of the ship is known.

Consequently, the AIS system, whose standards and schedule of operation are set by the International Maritime Organization (IMO), is a system designed to satisfy the requirements of the institutions and organizations and civilian companies engaged in maritime business in Turkey.

The AIS system can be used effectively for national security by the relevant institutions and organizations of Turkey 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 ships such as unique identification, speed, position, etc. The real-time tracking of civilian vessels navigating in the sea is an imperative requirement for the effective performance of tasks and activities such as maritime search and rescue, combating trafficking, and preventing maritime pollution. (TCS, 2010). 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 AIS Class-B CS

AIS Class-B CS enables to track all ships and vessels fitted with AIS equipment. Amendments have been made to the EC Directive 2244/2003 laying down detailed provisions regarding satellite-based vessel tracking systems and requiring fishing vessels of 15 meters of more in length to be fitted with AIS system. The production and standardization operations have been started in the international context for AIS Class-A equipment used by ships within the scope of the Convention for the Safety of Life at Sea (SOLAS) and AIS Class-B equipment with reduced features and used by ships outside the scope of the SOLAS Convention (TCS, 2010)

3.5 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 a capability of tracking only ships navigating at a close range from the coast, a project for Long Range Identification and Tracking (LRIT) System was developed by the IMO to track ships 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 high-speed craft of 300 gross tonnage 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 by IMO and the responsibilities of flag, port or coastal countries have been identified.

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

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

As per the Chapter V, Regulation 19/1 of the Convention for the Safety of Life At Sea (SOLAS), all cargo ships, engaged on international voyages, including high-speed craft of 300 gross tonnage and above, passenger ships, high speed train and mobile offshore drilling units are equipped with LRIT. The LRIT system is directly compatible with ships constructed on or after 31 December 2008 and the ships constructed before 31 December 2008 have been adapted to the system (TCS, 2010)

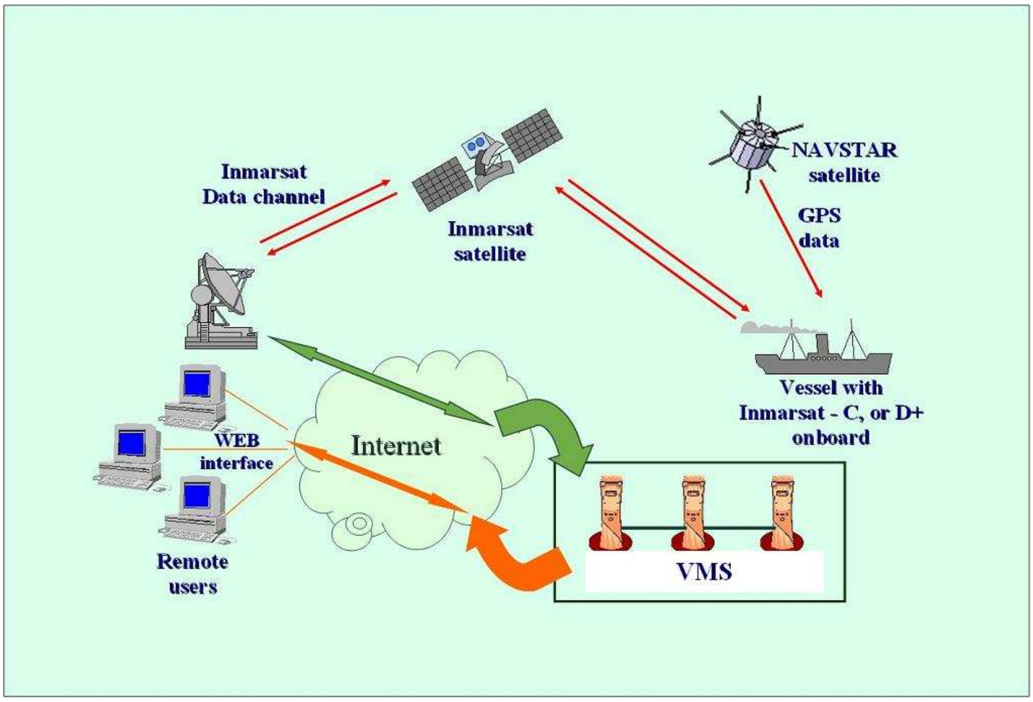

Figure 3.5 Design of the LRIT system (TCS, 2010)

"In the project for LRIT system, data exchange was commenced in a global context as of 30.09.2009. Turkish National LRIT Data Center was established by TÜRKSAT A.Ş in the physical environment of the Directorate of Radio Operation affiliated to the Directorate General of Coastal Safety on behalf of and under coordination of the Undersecretariat for Maritime Affairs." (TCS, 2010)

As declared by International Maritime Organization (IMO), the test process coordinated by the IMO and obligatorily applied for the integration of data centers into the global LRIT system was successfully completed on 08.03.2010 by the Turkish National LRIT Data Center.

Thanks to LRIT system, it is now possible to track Turkish flag ships all over the world and foreign flag ships navigating at a distance up to 1000 nautical miles from the coasts of Turkey.

3.6 Main Search and Rescue Coordination Center (MSRCC)

3.6.1 Cospas-Sarsat System

Cospas-Sarsat 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 by aircraft, ships and backcountry hikers in distress. 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 system which detects and locates emergency beacons activated at the frequencies 121.5 MHz, 243 MHz or 406 MHz by ships, aircrafts or individuals in distress and then starts search and rescue operations as soon as possible (Figure 3.6). Turkey has been involved in COSPAS-SARSAT system in the capacity of Ground Segment Provider as from June 11, 2005 (TCS, 2010)

Figure 3.6 Cospas-Sarsat system operation
(http://www.nss.gc.ca/site/Emergency_Beacons/cospas_sarsat_e.asp)

- Ground receiving stations, referred to as Local Users Terminals (LUTs), which receive and process the satellite downlink signal to generate distress alerts; and
- Mission Control Centers (MCCs) which receive alerts produced by LUTs and forward them to Rescue Coordination Centers (RCCs), Search and Rescue Points Of Contacts (SPOCs) or other MCCs.

In case of an accident, Cospas-Sarsat beacon equipment transmits distress signals in all directions. These signals are received by satellites and transmitted to the ground. Ground receiving stations, referred to as Local User Terminals (LUTs), receive and process satellite downlink signals, and transmit them to Mission Control Centers (MCCs) together with identification, position and other information. Mission Control Centers (MCCs) receive and evaluate signals transmitted by LUTs and extract necessary data (position, identification) and forward them to the relevant Rescue Coordination Center (RCC). RCC performs necessary search and rescue operations based on the information received (TCS, 2010) COSPAS-SARSAT System Ground Segment Equipments installed in Turkey are given below:

- MCC (Mission Control Centre) Unit: Installed at the Main Search and Rescue Coordination Center of the Undersecretariat for Maritime Affairs.
- Geostationary Earth Orbit Local User Terminal (GEOLUT) and Low Earth Orbit Local User Terminal (LEOLUT) Units: Installed at Esenboğa Airport.
- Rescue Coordination Center (RCC) Units: Installed at the Coast Guard Command, the Main Search and Rescue Coordination Center of the Undersecretariat for Maritime Affairs, Atatürk Airport and Esenboğa Airport.

3.6.2 MEOSAR = SAR on GNSS (Global Navigation Satellite System)

Medium Earth Orbit Search and Rescue (MEOSAR) system, known as the next generation COSPAS-SARSAT system, can detect the position of beacons much more quickly and precisely than the existing system thanks to much larger footprints of MEO satellites. Approximately 80 satellites will enter into service with the commissioning of the MEOSAR system. (Kılıç & Solak, 2010)

Medium Earth Orbit (MEO) satellites function to form a larger footprint than the existing Low Earth Orbit (LEO) satellites and thus provide a global coverage. MEO satellites also enable the detection of the position of beacons much more quickly and precisely than the existing system since one LUT can track more than one MEO satellite simultaneously. The objectives of MEOSAR system are:

- To expand the existing Cospas/Sarsat (C/S) System
- To modernize the Cospas/Sarsat (C/S) System for the next years
- To increase Detection Rate, Location Sensitivity and Confidence of 406 MHz beacons

Features of MEOSAR:

1- Always visible MEO satellites.
2- Beacons visible by more than one satellite simultaneously.
3- Less interference.
4- Higher detection probability.
5- Detection of position with a single signal.
6- Capability to keep track of moving beacons.

Within the scope of MEOSAR system, 9 satellites have already been launched by the USA and the countries with MEOLUTs installed started to collect data via these satellites for analysis purposes. (Kılıç & Solak, 2010)

CHAPTER FOUR
INTEGRATED MARITIME SURVEILLANCE SYSTEM

4.1 The Installation of an Integrated Maritime Surveillance System in the Aegean Region

The continuous surveillance of borders, including maritime boundaries, of a country like Turkey, which is surrounded by seas on three sides, is of high importance with regard to security and national defense. Furthermore, continuous surveillance is also necessary due to 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 Turkey which has an important potential for maritime trade.

The utilization and improvement of maritime trade is of vital importance to Turkey, which is the 16^{th} largest economy of the world and an important 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, it is an imperative for Turkey to monitor its coasts and especially the Aegean Sea with numerous gulfs and cliffs and thousands of nested islands. The importance of monitoring and tracking the marine traffic in the Aegean Sea becomes apparent. Considering the chronic disputes with the neighboring countries, the importance of surveillance and monitoring of traffic in the Aegean Sea for Turkey becomes more apparent.

Turkey, which is located at the junction point of three continents, is an important 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 km, excluding the geographical formations such as islands, islands and rocks whose sovereignty has not been transferred by agreements, is not only of commercial importance for Turkey, but also of great importance for other world countries. Furthermore, the Aegean Sea is a special zone where even minor events draw attention of the public and thus it is targeted by terrorists and interest groups aiming to create regional instability. Considering this, the Aegean Sea where terrorist actions can make tremendous and quick impact, should be protected meticulously and kept under control without causing any crisis or allowing terrorist actions.

The surveillance of maritime boundaries is a must for Turkey, which depends on its ports for 90% of its foreign trade activities in parallel with its increasing tourism revenues and growing economy.

Furthermore, Turkey, which has ongoing territorial disputes with Greece, highly needs surveillance systems for security and defense purposes in order to determine border violations and take necessary measures to respond to emergency situations, such as accidents, in the areas of responsibility.

4.2 Radars

The term “radar” is an acronym for “Radio Detection and Ranging”. The radar, initially used only for the detection of enemy aircrafts, is now used by all world nations despite various definitions.

4.2.1 The History of Radar

Although radars were developed and used during the World War Second, the principles of radar detection date back to the electromagnetic theory. In 1886, H. Hertz used Maxwell’s equations to demonstrate the reflective properties of electromagnetic waves. Hertz found that radio waves could be reflected by metallic and dielectric bodies. The initial experiments of Hertz were carried out with very short waves and the subsequent experiments were conducted with longer waves (DHO, 1987).

In 1922, Marconi recognized the potential of using short wave radio for the detection of objects and envisaged continent-to-continent radio communication. Nevertheless, he did not appear to receive support to carry these ideas further at the time. The other projects of him, including radar detection and the propagation of very short waves over distances much greater than the optical line of sight, were not accepted. Moreover, he envisaged the use of radio waves to point-to-point transfer of power without using any wires.

Inspired by Marconi, A. H. Taylor and L. C. Young realized their ideas for radio detection by experiments. They detected a wooded ship in the fall of 1922 by using continuous wave (CW) interference radar with a 5-meter wavelength and a separate receiver and transmitter (Carlıoğlu, 2005)

Pulse technique was first used in 1925 by Breit and Tuveto to perform measurements of the Earth’s ionosphere; however, only after 10 years could aircrafts be searched by means of pulsed radar.

CW radars are the first experimental radars affected by the interference produced between the direct signal received from the transmitter and “Doppler frequency shift” pulse reflected by the target. The resulting is a signal like the effect of magnets on a TV screen, and thus this type of radar was originally called “CW interference radar”. Today, it is called “bistatic CW radar”, which was initially used frequently instead of CW monostatic radars. On the other hand, pulsed radars emerged with the development of necessary components, especially electron tubes and pulse receivers. (Carpentier M. L.,1968) , (Carlıoğlu, 2005)

The development of radar technology has gained speed due to warfare requirements. However, radar has also been used in many civilian applications for airborne and maritime researches. Radar technology is still in a development process. Although not fully satisfying in many applications, radar will remain as the only method for the detection of energy-emitting objects at a long range until a new method is developed. (Carpentier, 1968) , (Carlıoğlu, 2005)

4.2.2 The Basics of Radar

In general, radar consists of electronic equipment used for the detection of objects. By means of various electronic systems and using sound waves, radar enables to obtain information regarding the location of objects at a long range far beyond what the unaided eye can see. The basic principle of operation of radar is shown in Figure 4.1.

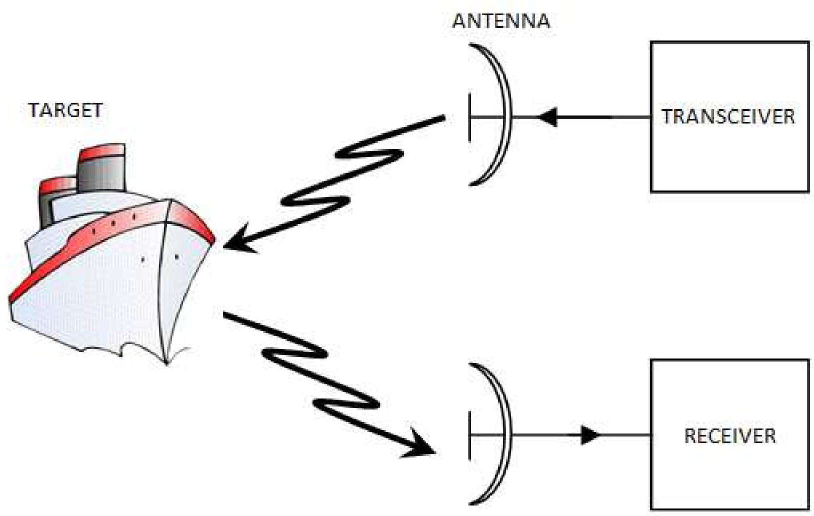

Figure 4.1 Basic principle of operation of radar

The electromagnetic waves produced by the transmitter are radiated by the antenna and when these come into contact with an object (target), they are usually reflected and/or scattered in all directions. Then, the receiver processes some portion of the reflected energy captured by the receiving antenna and returned to the transmitter. The nature of the echo signal provides information about the presence, relative velocity and range of a target, as well as its azimuth relevant to the radar.

Distance to a target is determined by measuring the time of time it takes for the pulse to reach the target and return. Considering that electromagnetic energy travels at the speed of light, the distance to a target is calculated as $r = \frac{Cxt}{2}$ (Carpentier ,1968)

The period of time between pulses transmitted by the radar should be long enough for any echo signal to return and be detected by the receiver, before the next pulse may be transmitted, and echo signals should not overlap. Therefore, the pulse repetition rate is determined by the longest range at which targets are held. If the pulse repetition frequency is too high, echo signals from the target may be detected after the transmission of the next pulse, resulting in ambiguities in range measurements. These are called second time around echoes. Unless such echoes are received intentionally, they will cause us to understate the range of the target and thus give rise to misleading results and wrong decisions. (Carpentier, 1968)

4.2.3 Block Diagram and Operation of Radar

The operation of a typical radar utilizing a magnetron in the transmitter as an oscillator can be summarized as follows (Figure 4.2):

The timer, also used as a trigger generator, generates a train of short-term pulses at a certain pulse repetition frequency. These pulses trigger the modulator to generate the pulses for the transmitter. The modulated RF pulses produced by the transmitter are fed to the antenna and then radiated into space (Ewell,1981).

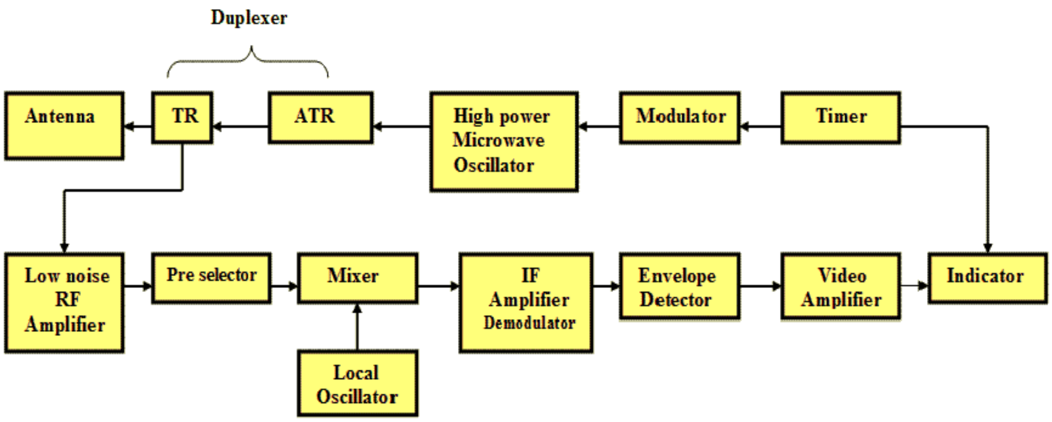

Figure 4.2 Block diagram of a simple pulsed radar (Radar Diagram, nd, http://www.radartheory.8m.com)

As the same antenna is used by radars during transmitting and receiving cycles, the echo signal reflected by the target again returns to the receiver through the antenna. Anti-transmit-receive (ATR) switch, which has no function during the triggering of the transmitter, deactivates the transmitter and enables the echo to canalize into the receiver in order to prevent the returned echo from fading away by dissipating in the transmitter. Transmit-receive (TR) and ATR switches are components of the duplexer. (Carpentier ,1968) , (Sonnenberg, 1963)

Radar receivers are generally of superheterodyne type. Certain microwave radar receivers do not have a RF phase and thus use the mixer as the first phase. “Mixer and oscillator circuits reduce the returned RF signal into IF phase where it is amplified much easily at low frequencies by high-gain and narrow-bandwidth amplifiers. A klystron may be used as a local oscillator.” (Carlıoğlu, 2005; p.60)

The IF signal is demodulated by the envelope detector and then amplified by the video amplifier to operate the indicator. The indicator, usually a monitor, displays the accurate position of the target on the scope together with the original timing information and the azimuth of the target in the direction of the antenna.

“A-scope and Plane Position Indicator (PPI) are the major indicators using CRT. As shown in Figure 4.3 (a), A-scope displays amplitude (y-axis) and range (x-axis) of targets, but does not display azimuth information” (Carlıoğlu, 2005; p.55) On the other hand, PPI displays range and azimuth of targets in polar coordinates (Figure 4.3 (b)).

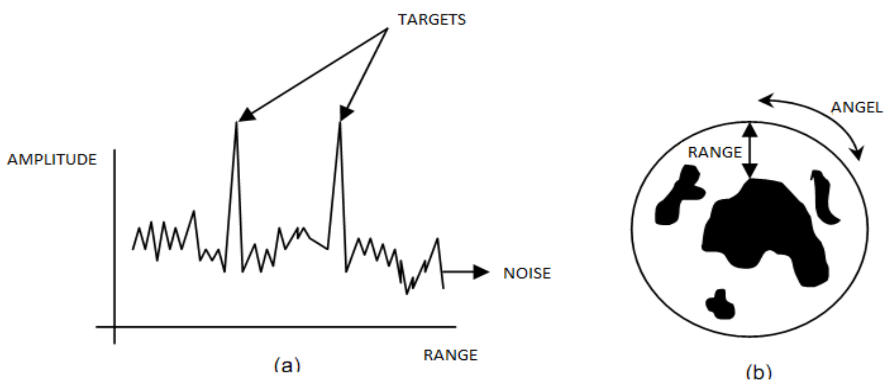

Figure 4.3 A-Scope and PPI (Carlıoğlu, 2005)

4.2.4 Radar Frequencies

In the Figure 4.4 shown that general radar frequencies and electromagnetic spectrum and radars have operated at a frequency band of 25-70000 MHz up to the present. But today, it is not accepted as the precise frequency limit. (Ewell, 1981).

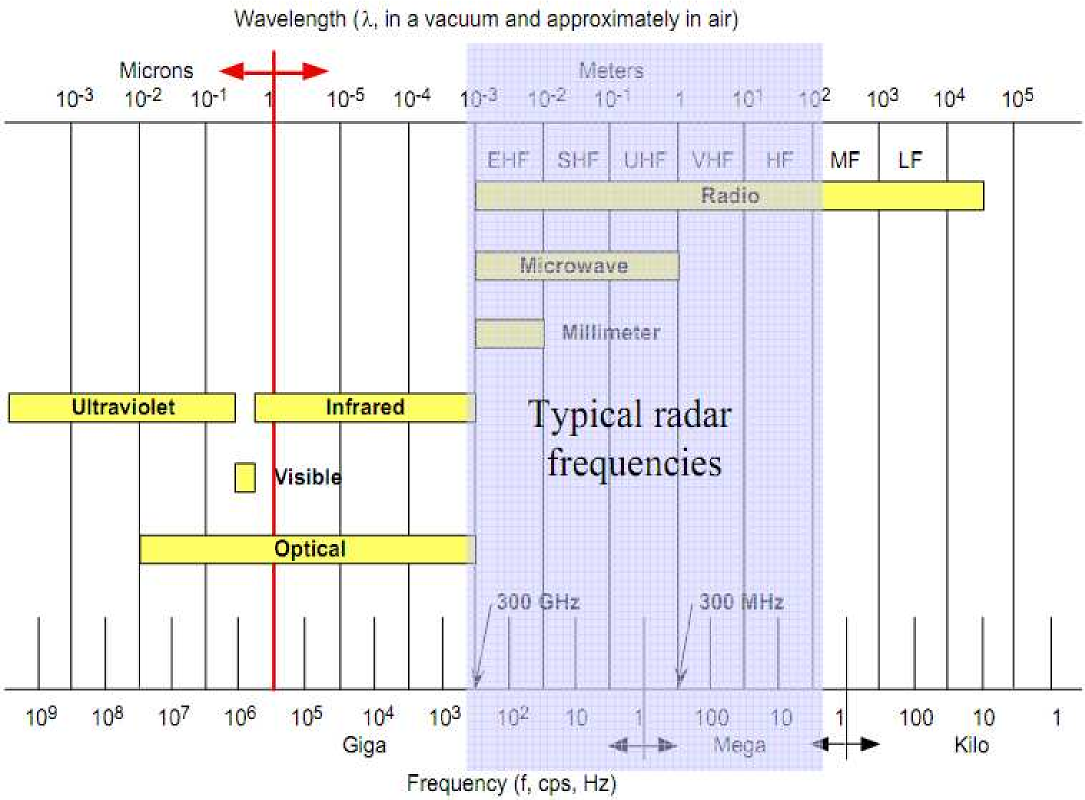

Figure 4.4 Radar frequencies and electromagnetic spectrum (Jenn, 1999)

In the past, radar engineers designed radars to operate at about 25 MHz due to lack of appropriate devices operating at high frequencies. However, such frequencies are now regarded as very low. Although very high transmitter power levels are reached at low frequencies, such low frequencies are not used in many applications due to low resolution and azimuth accuracy at low frequencies for practical antenna dimensions. For a certain antenna aperture, the antenna beam width will increase and the target azimuth accuracy will decrease as the frequency is reduced. (Carlıoğlu, 2005)

The letter designation system used originally for identifying classified military information still retains its validity in terms of practicability and general acceptance.

Even though the precise frequency limits are not defined, the related frequency bands are given in Table 4.1. (Brookner,1977)

Table 4.1 Radar frequency bands (Jenn, 1999)

Band Designation	Frequency Range	Usage
HF	3–30 MHz	OTH surveillance
VHF	30–300 MHz	Very-long-range surveillance
UHF	300–1,000 MHz	Very-long-range surveillance
L	1–2 GHz	Long-range surveillance En route traffic control
S	2–4 GHz	Moderate-range surveillance Terminal traffic control Long-range weather
C	4–8 GHz	Long-range tracking Airborne weather detection
X	8–12 GHz	Short-range tracking Missile guidance Mapping, marine radar Airborne intercept
K_u	12–18 GHz	High-resolution mapping Satellite altimetry
K	18–27 GHz	Little use (water vapor)
K_a	27–40 GHz	Very-high-resolution mapping Airport surveillance
millimeter	40–100+ GHz	Experimental

4.2.5 Radar Applications

Radars are now used for many purposes, especially on land, in the air and at sea, and will surely be improved to be used in the space.

Civilian radar applications

Apart from military applications, radars are mostly used for navigational purposes in the air and at sea. Air traffic control radars are in continuous operation both at airports and between air terminals. Radars are used for providing safe landing with the help of the Ground Controlled Approach (GCA) system under adverse weather conditions. Airborne weather avoidance radars enable the aircrafts to avoid storm.

At sea, radar has always been a favorite and important device especially under adverse weather conditions. On land, radars are mainly used to detect typhoons and tornadoes and measure traffic speed on roads.

Military radar applications

Military radar applications are similar to civilian applications, especially with respect to radars used for navigational purposes. Radars are also used in weapon surveillance and control systems.

Scientific radar applications

Radars are used by researchers to gather information about meteorology, meteors and other heavenly bodies, to track satellites sensitively, and for radio astronomy purposes.

4.2.6 Microwave Radar

The term "microwaves" is used to describe electromagnetic waves with a wavelength of 1 cm to 1 m. The corresponding frequency range is 300 MHz up to 30 GHz. The electromagnetic waves with a wavelength of 1 to 10 mm are called millimeter waves. The infrared radiation spectrum comprises electromagnetic waves with a wavelength in the range of 1 μm to 1 mm. Beyond the infrared range is the visible optical spectrum, the ultraviolet spectrum, and finally X-Rays. Several classification schemes are in use to designate frequency bands in the electromagnetic spectrum. These classification schemes are summarized in Table 3.1. The term "microwave engineering" 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. That is, 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 aircrafts or high hills in order to cover larger areas. During the World War Second and shortly afterwards, 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 aircrafts and ships. Even today, radars, in its 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 a reflector or lens-type antennas as repeater stations installed at certain intervals along the communication path. These links are often seen by frequent travelers because of their frequent use by highway authorities, utility companies, and television networks. A further means of communication by microwaves is the use of satellites as microwave relay stations. (Görür, 1996)

4.2.7 HF Radar Systems

The basic principle of operation of a HF groundwave radar is that a radar signal propagates along the water surface until it vanishes in the horizon. HF surface wave radar (HFSWR) provides active surveillance within the Exclusive Economic Zone covering an area of 200 nautical miles. It is an unmanned sensor operating in all maritime conditions and providing the creation of a coast-based recognized maritime picture. HF radar uses “vertically polarized HF electromagnetic signals” that propagate along the ocean surface and beyond the horizon. This capability enables HF radar system to be the one and only radar system which detects all small vessels at a very long range and all low level flying aircrafts. (Sevgi & Ponsford, 1999)

HF radars are classified as skywave and groundwave (surface wave) radars. Especially the ocean countries, such as the USA and China, have used skywave HF radars operating at high frequencies (15-30 MHz) since 1950. For example; the USA can cover the Atlantic Ocean up to the coasts of Europe, and Pacific Ocean up to the coasts of China. As the installation and operation of skywave HF radars are very expensive, the USA, which covers the whole world via hundreds of satellites installed at different orbits, is about to withdraw this system. Even though the resolution of groundwave HF radars is not as high as microwave radars, acceptable performance may be achieved by means of powerful software. (Sevgi & Ponsford, 1999)

The coverage of HF radars and microwave radars are shown in Figure 4.5 (Sevgi,L.,1999) . The frequently used ASR-10SS-8 and ASR-10SS-16 microwave radars cover an area up to the horizon line, whereas SWR_503 Surface Wave Radar and ASR-23SS-16 cover an area beyond 200 nautical miles.

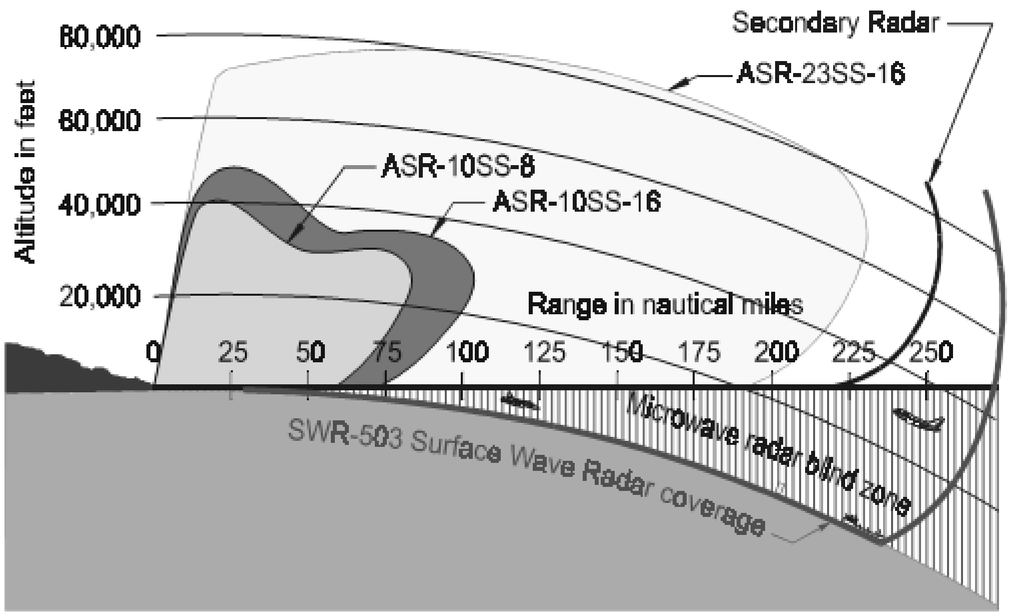

Figure 4.5 Coverage of microwave and HF surface wave radars (Sevgi,1999)

HF radar was designed to protect and monitor coasts and shores. The fields of application of HF radars are given below:

- Coastal protection and surveillance,
- Enforcement of laws,
- Search and rescue,
- Combating human trafficking,

- Protecting seas and shipping industry,
- Fighting against drugs and preventing smuggling (Carlıoğlu, 2005)

Beyond the horizon, HF radars can operate with vertically polarized antennas located close to the conductive salt water. Therefore, they are largely ineffective on land and in the freshwater. The main system consists of 3 components:

- Receiver,
- Transmitter,
- Data Processing Center

Receiver and transmitter blocks may be combined for monostatic operations. The distance between receiver and transmitter blocks is about 80 km and these blocks may be established as a command and control center at a far distance from the data processing center. Wires or equivalent communication systems, as well as satellite communication systems, may be used for the control of system between blocks and transfer of information such as radar data. (Carlıoğlu, 2005)

Problems in HFSWR

The new type HFSWR systems may be installed at any time due to the existing technology infrastructure. However, these systems require efficient and smart software. All signal processing functions of radars should necessarily be used in the heavily used HF area with high ambient noise levels (Sevgi, 2002). The problems of these systems, which remain unsolved, include:

- Unwanted signals and echoes from the ionosphere (ionospheric clutter)
- Sea clutter which is 20-30 dB higher than a signal
- Ambient noise

It is impossible to solve these problems, each having a non-linear, in-homogeneous, time-varying, and stochastic character, via software based on simple signal processing algorithms. The behavior of the above mentioned signals has yet not been modelled close to reality. For example; a model of sea clutter for use in the case of high seas has yet not been developed. Likewise, the behaviors of the ionosphere relevant to the stratum and its short, medium and long-term of movements can not be estimated. Therefore, the attempts to avoid the effects of signals from such media and to filter such signals cannot go beyond the theory and thus cannot be put into practice. Nevertheless, HFSWRs are one of the major components of the Integrated Surveillance Systems. (Sevgi, 2002)

4.3 The Installation 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 effective prevention of any form of smuggling and illegal immigration,
- To improve the effectiveness of maritime search and rescue operations,
- To control fishery activities and maritime resources,
- To improve 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.

4.3.1 Components of the Integrated Maritime Surveillance System

Surface Wave Radar: The type of radar to be 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. The coverage of microwave radars is limited to the horizon line (40-50 km), whereas HF radars can cover an area of 500 km. However, the accuracy and resolution of HF radars are lower than microwave radars. Radars have different advantages and disadvantages. Therefore, the above mentioned two radar systems should be treated as the complementary of each other and used accordingly. X-Band microwave radars, providing a coverage of approximately 50-60 miles in the Aegean Region in direct proportion to the horizon line and elevation, indicate that Turkey is competent to monitor its own territorial waters and international transit routes in its region of interest. The resolution of radars in this limited area is higher than that of HF radars and the importance of early and accurate detection is apparent. HF radars using American and Canadian groundwave propagation perform surveillance of an ocean area of 200 miles. It is known that the probability of escape from detection in such a wide area is low. Furthermore, microwave radars can also be used an operated in mobile mode. (Ding & Kannappan & Benameur& Farooq & Kirubarajan,2003)

Other Sensors and Information Sources: The ships detected by radars may be identified by means of a database containing the records, obtained via the AIS system, of those ships registered to IMO. Furthermore, even webcam marine images published on the internet may be used as an information source to build a Recognized Maritime Picture. Moreover, the projects for monitoring marine traffic, as mentioned in Chapter Two, are the complementary elements of the Integrated Maritime Surveillance System.

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

During multi-sensor data fusion operation, track fusion (data fusion) is performed by statistically fusing data from sensors considering the uncertainties in hardware and tracking algorithms of sensors.

Data Distribution Server: Data Distribution Server will provide all required data and services for authorized clients.

IMS Administration: Manages changing configurations, operating and non-operating conditions of IMS system, user accounts and security, 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 where data transfer infrastructure is constructed. For data transfer on land, satellite systems may be used at high points where microwave radars are deployed.

The communication between sensors and Data Fusion Engine may be accomplished by using TCP/IP protocol. It is recommended to use TCP/IP protocol between the local site and operations center. On the other hand, UDP protocol should be used at the local site. Figure 4.6 shows the infrastructure of communication between Local Sites and Operations Center. TCP/IP protocol is reliable, while UDP protocol is fast. This means that data will be processed fast at the local site and then reliably transferred to the operations center. (Ding & Kannappan & Benameur& Farooq & Kirubarajan,2003)

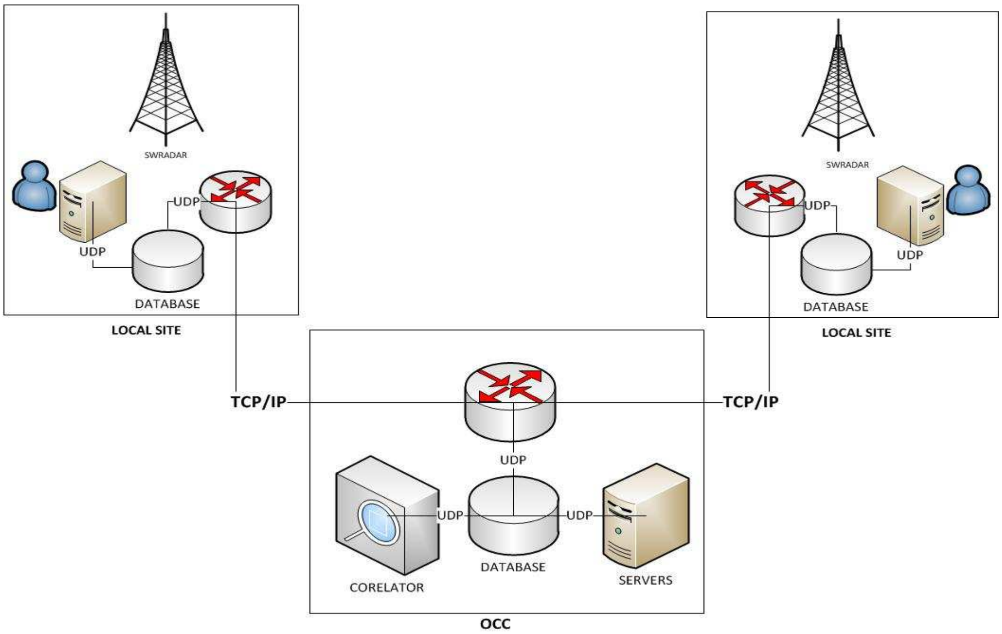

Figure 4.6 TCP/IP and UDP communication between local sites and OCC.

Figure 4.7 shows an architecture formed by a combination of Local and Regional Maritime Surveillance Systems. The data derived by HF surface wave radars or microwave ground radars used in Local and Regional Maritime Surveillance Systems is sent – after the correction of overlapping information – through the network transport layer to the Operations Center and then transferred to other users by being fused with other information sources via Data Fusion Engine.

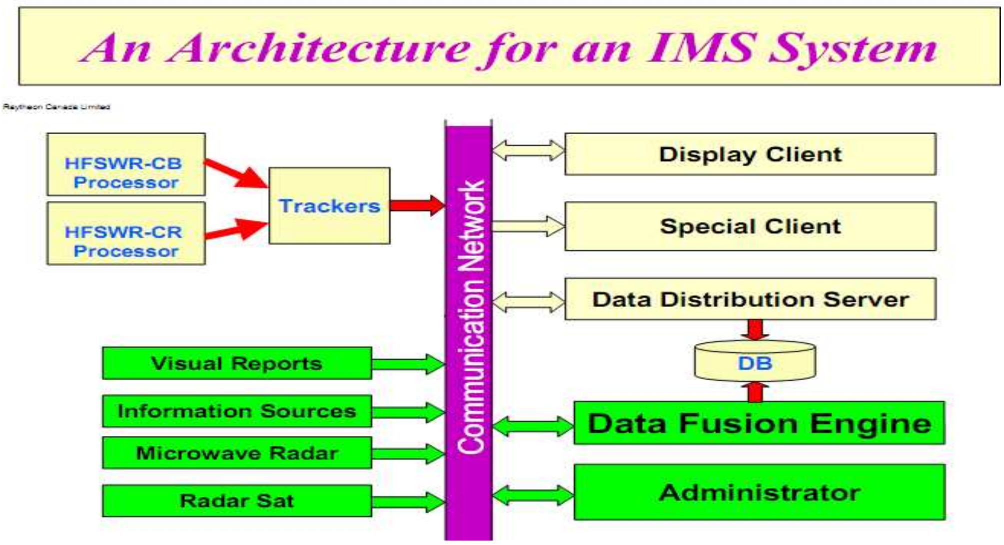

Figure 4.7 The proposed IMS architecture (Ding & Kannappan & Benameur& Farooq & Kirubarajan,2003)

CHAPTER FIVE
VIEWSHED ANALYSES OF MARITIME SURVEILLANCE RADARS

5.1 Introduction

Radars are one of the major elements of integrated maritime surveillance systems. The target detections or tracks derived from radars help to build a recognized maritime picture with the aid of 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 emergency situations. In order 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. Considering the Aegean Sea has numerous islands, HF radars were not used in this case as they lose conductivity on lands.

The Aegean Sea, having different features from the Black Sea, the Mediterranean and the Sea of Marmara, and even most seas of the world, has been chosen for our analyses as it has numerous cliffs, bays and thousands of islands. In order to monitor 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. Figure 5.1 shows the area formed by the related maps.

The purpose is to simulate, by means of GIS tools, the change in the capability of monitoring the current situation in case radars of different types are placed at different positions on the maps built. For this purpose, it is necessary to build a structure to model the topography on digital base maps. In the first stage of the application, different base maps used for the interpretation of elevation data is handled and then the possible analyses on such maps are assessed.

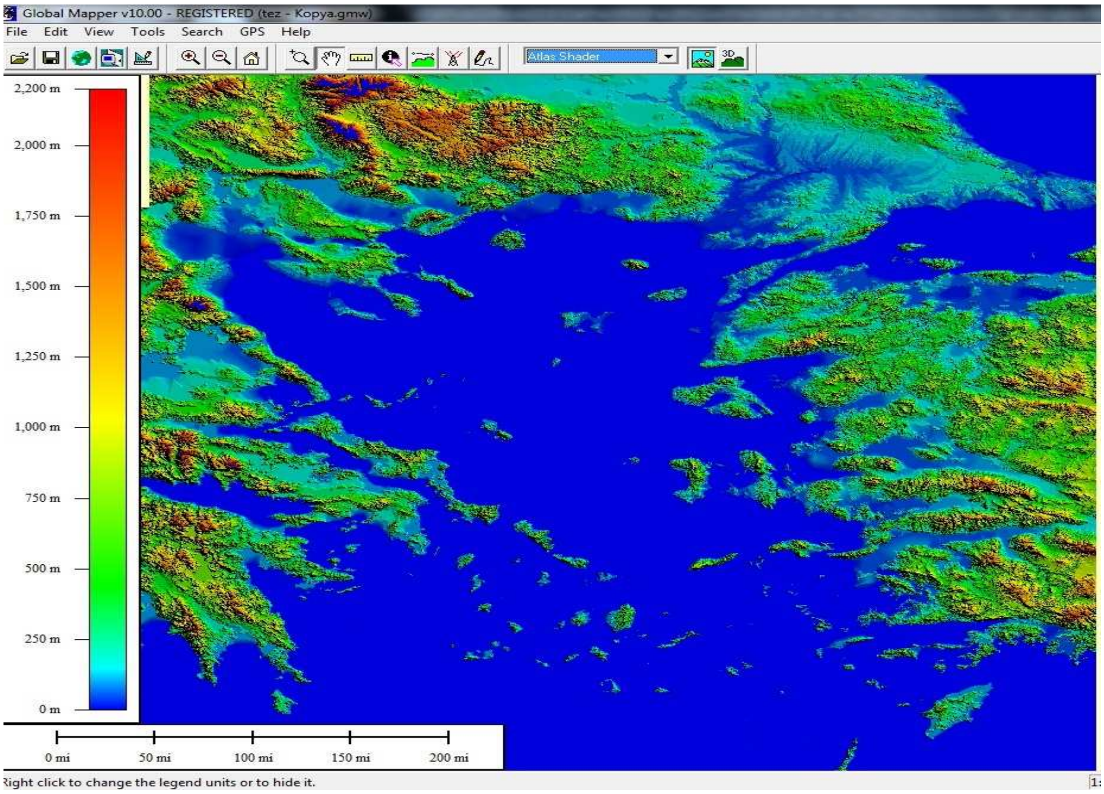

Figure 5.1 DTED1 map of the aegean sea region

5.2 Using ArcGIS's Vector TIN Models

For viewshed analyses, the availability and efficiency of ArcGIS, which is the most used GIS software in such analyses, were checked first. For this purpose, the maps showing the topography of the Aegean Sea and consisting of contour lines were converted into 3-dimensional plots and thus a 3D digital base map was constructed. Attempts were made to convert 3D base maps into Triangular Irregular Networks (TIN) format by means of the modelling tools of ArcGIS software. TINs are a form of vector based digital geographic data and are constructed by triangulating a set of vertices. The vertices are connected with a series of edges to form a network of triangles. Figure 5.2 shows the logic of TIN format.

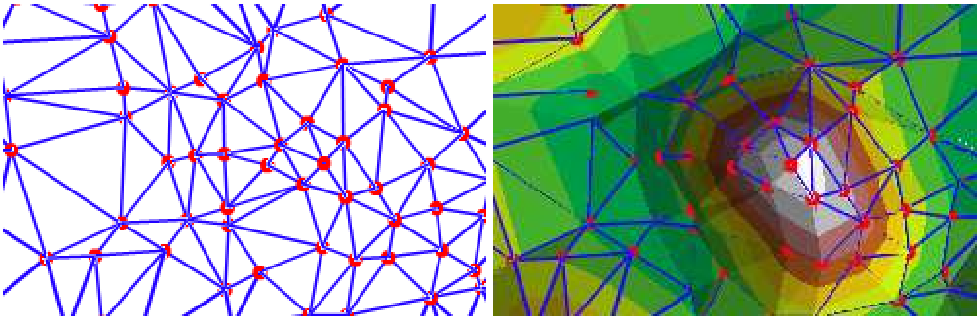

Figure 5.2 TIN format (TIN Surfaces, nd, http://www.esri.com)

Upon detailed examination of the model developed for viewshed analyses by converting contour lines into TINs, we noticed certain erroneous planes which obstruct getting a clear view of sea surface. After detailed inspection of the model, such errors were proved to be associated with the program module used for the formation of TINs. The model based on TINs formed by connecting the nearest three points connects even the smallest elevations or erroneous elevations with the nearest elevation values in areas with an elevation of zero, such as sea surface, thus causing insignificant elevations at sea surface. Furthermore, some problems were experienced in certain parcels, such as 28 E – 35 N, in opening the map after its conversion into a TIN map. Consequently, we decided not to use ArcGis software for viewshed analyses due to the above mentioned errors. Figure 5.3 shows the related TIN maps.

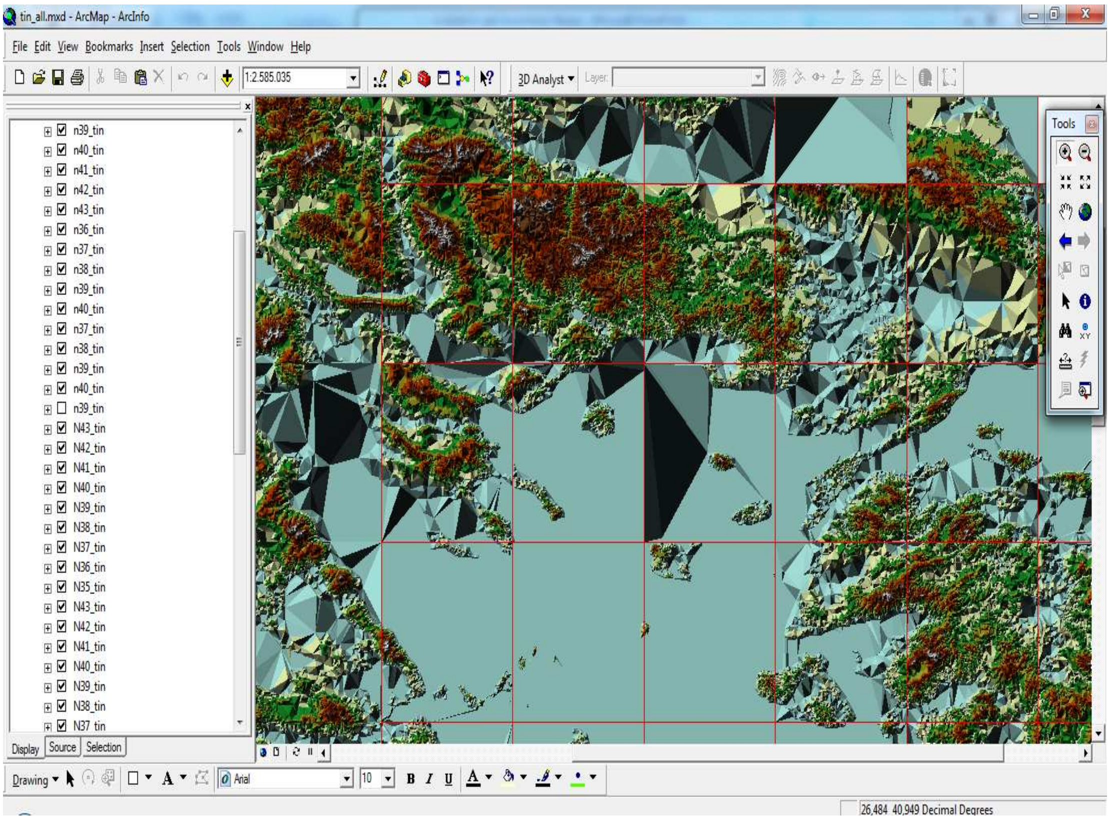

Figure 5.3 Errors in TIN maps constructed by ARCGIS software

5.3 Properties of Digital Terrain Elevation Data [DTED] Maps

DTED Level 1 maps were used in our analysis. The characteristics of DTED 1 Maps used for our analyses between the latitudes E-20 and E-36 and between N-35 and N-41 are as follows:

In support of military and other applications, the National Imagery and Mapping Agency (NIMA) has developed standard digital datasets (Digital Terrain Elevation Data – DTED) which provides basic quantitative data for systems and applications that require terrain elevation, slope, and/or surface roughness information. DTED Level I maps contain basic medium resolution elevation data sources for all military activities and systems that require landform, slope, elevation, and/or gross terrain roughness in a digital format. DTED Level 2 and other DTED maps provide higher resolution data. Table 5.1 shows the properties and resolution values of DTED maps.

Table 5.1 Properties of DTED Maps Reference: (DTED Properties, nd, http://www.globalsecurity.org)

DTED Level	Post Spacing	Ground Distance	Row x Column	Tile Size
1	3.0 sec	~100 m	1200 x 1000	1 x 1 degree
2	1.0 sec	~30 m	3600 x 3600	1 x 1 degree
3	0.3333 sec	~10 m	900 x 900	5 x 5 minute
4	0.1111 sec	~3 m	540 x 540	1 x 1 minute
5	0.0370 sec	~1 m	810 x 810	30 x 30 second

5.4 Using Global Mapper’s Raster DEM Models

“Global Mapper has built in functionality for distance and area calculations, raster blending, feathering, spectral analysis and contrast adjustment, elevation querying, line of sight calculations, cut-and-fill volume calculations, as well as advanced capabilities like image rectification, contour generation from surface data, viewshed analysis (including Fresnel) from surface data, watershed delineation, terrain layer comparison (including differencing), and triangulation and gridding of 3D point data. Repetitive tasks can be accomplished using the built in scripting language or comprehensive batch conversion functionality.” (Overview Of The Global Mapper, (n.d.)., http://www.globalmapper.com/product/overview.htm)

It is a considerable advantage that Global Mapper also supports DTED1.dt1 format and carries out viewshed analyses using the available data in this format.

Data display and processing settings should be made so that Global Mapper uses the available data although the default format is dt1. Some errors were detected during the first loading of the map constructed. In the Aegean Region, certain false terrain elevations such as 36000 meters were calculated. Therefore, the maximum valid elevation in our map was set to 2200 meters as default. Figure 5.4 shows the errors after the entry of this value as the maximum valid elevation. Furthermore, a custom shader was used to increase the visual perception.

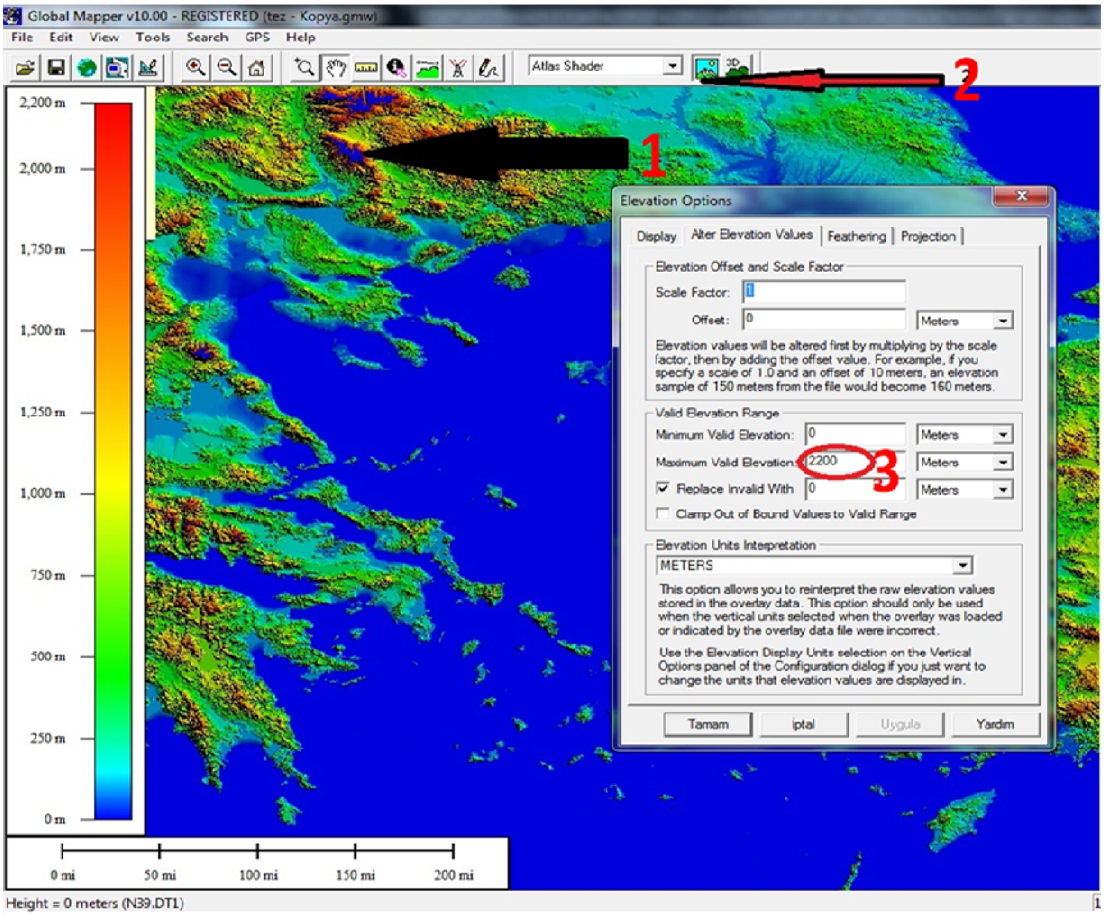

Figure 5.4 Global mapper settings

Global Mapper Display Settings

The area 1 shows an erroneous zone above the elevation of 2200 meters. However, this zone was ignored as it was not significant for the viewshed analysis in question. The area 2 shows the appearance of the map after a standard shading process. The sensitivity of visual perception is low especially at sea level. The area 3 shows the maximum valid elevation set to 2200 meters as default.

5.5 Radar Viewshed Analyses

The coverage of microwave radars is limited to the horizon line, thus requiring them to be deployed on high hills to increase the range of visibility. Therefore, we should deploy our radar at the peak point of the area chosen for viewshed analysis. 3D View Tool of Global Mapper (Figure 5.5) will help to identify the peak point. Buttons are available to increase the level of elevations decrease level of seas by means of 3D View Tool and thus enabling to identify the peak point.

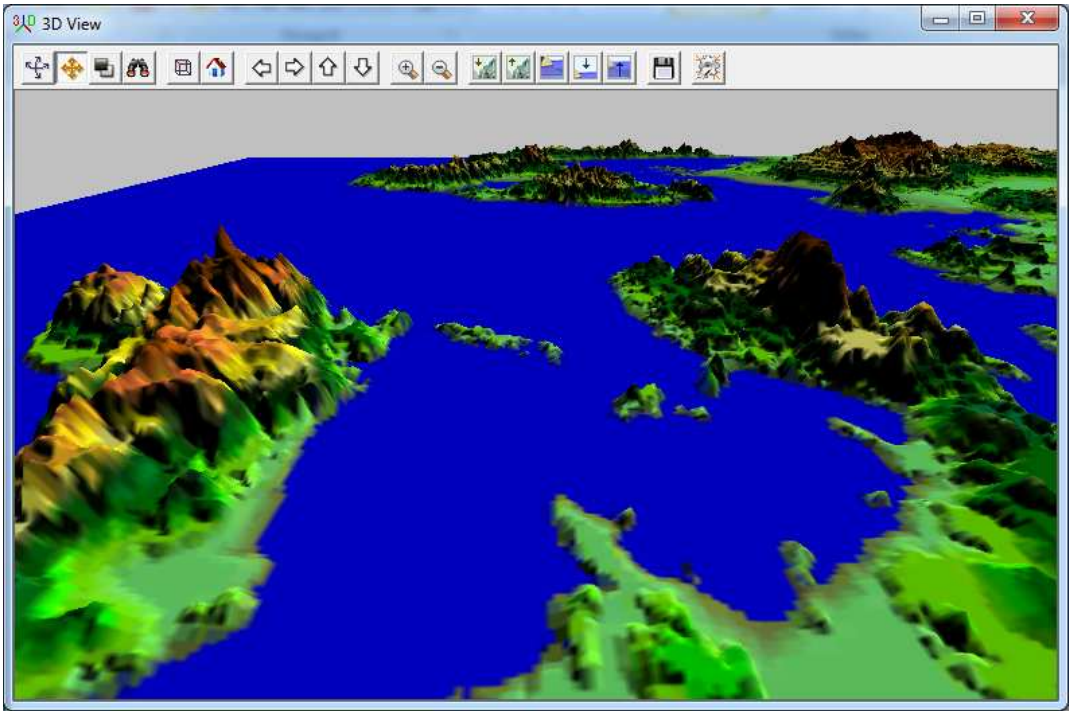

Figure 5.5 Global mapper 3D view tool

Likewise, 3D Path Profile / Line of Sight Tool of Global Mapper was used to identify the peak point. This tool enables to display the elevations on the selected line and position them at the desired point. However, the peak point does not mean the best coverage. For example; a hill with an elevation of 1250 meters behind a hill with an elevation of 1200 meters does not provide the best angle of vision. As shown in Figure

5.6, the area cut by a hill of 1200 meters in elevation in front of a hill of 1250 meters in elevation is a blind zone.

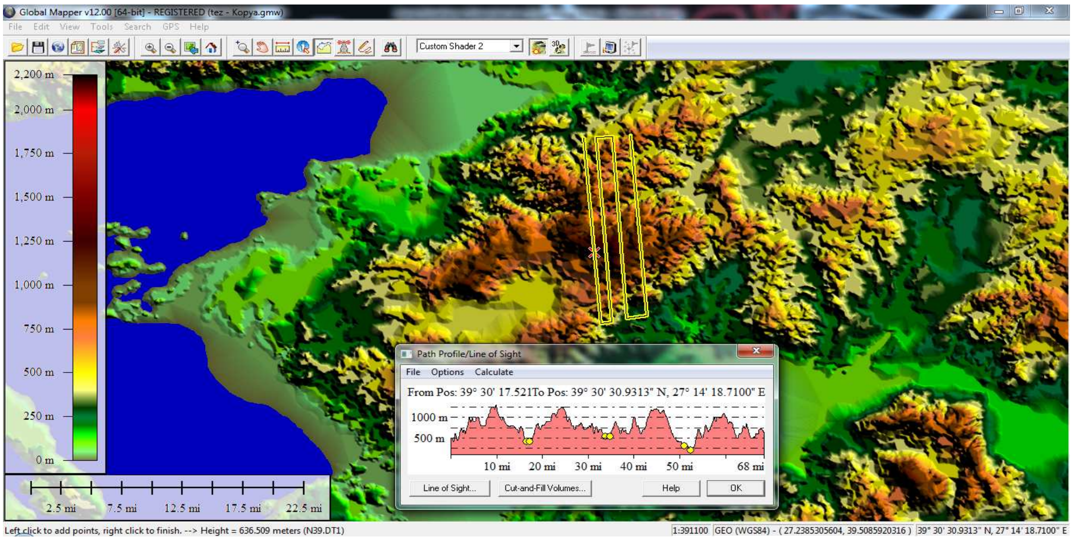

Figure 5.6 3D path profile / line of sight tool

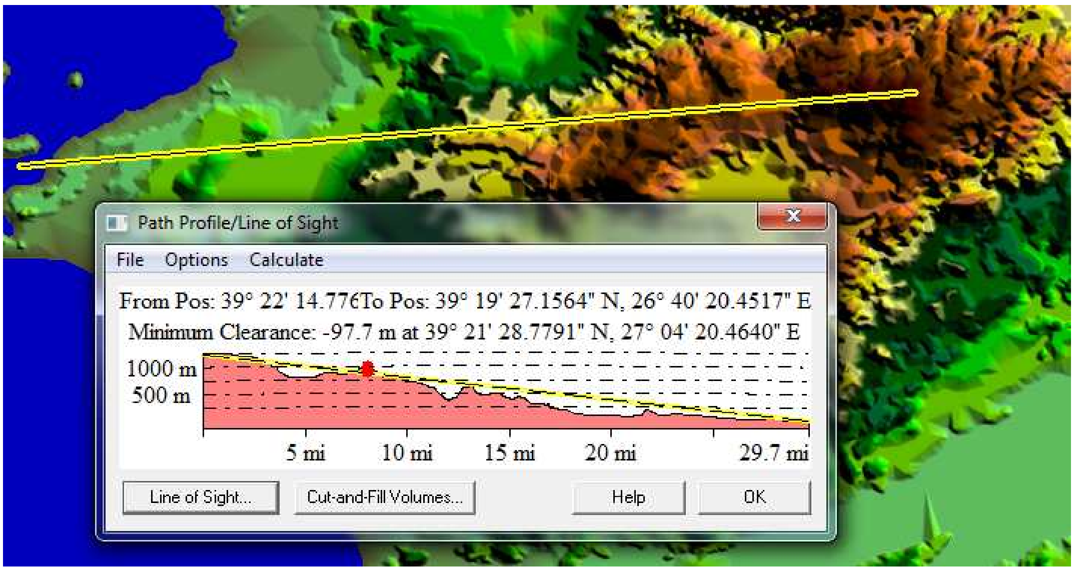

Figure 5.7 Line of sight

Figure 5.7 shows the field of view from an area of 1230 meters in elevation. The zone located in front of the area of 1000 meters in elevation is a blind zone.

5.6 Viewshed Analysis with a Microwave Radar

X-Band radars, operating in the frequency range of 8 to 12 GHz, are used for maritime surveillance purposes. Most companies worldwide produce X-Band Radars for both military and civilian purposes. 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.

Standard Radar Characteristics

Low altitude air and surface fully solid-state surveillance radar. Designed to answer new coastal surveillance needs including round the clock, long range surface and low altitude targets detection.

Basic Characteristics of a Standard Coastal Surveillance Microwave Radar

- **Surface channel**
- **Frequency**
  - Operation in X band for better surface detection
  - Agility bandwidth: up to 600 MHz
  - Number of frequencies: up to 64
- **Transmitter**
  - Peak Power: modular: 250 or 500 or 1000 W
  - Duty cycle: up to 15 %
- **Antenna**
  - Rotation speed: 6, 10 and 20 Rpm
  - Azimuth resolution: 0.6°
  - Polarization: linear and circular
- **Range**
  - Instrumented range: up to 100 nm

- Range resolution: down to 4 m

• **Surface detection capability (80 %)**

–*Radar altitude = 85 m*

- RCS = 1 m², 1 m ASL: 15 nm
- RCS = 100 m², 5 m ASL: 22 nm

–*Radar altitude = 1000 m*

- RCS = 20 m², 1 m ASL: 45 nm
- RCS = 100 m², 5 m ASL: 65 nm

-*Air detection capability* (80 %)

- Ceiling = 3500 feet
- RCS = 3 m², 500 feet ASL: 35 nm

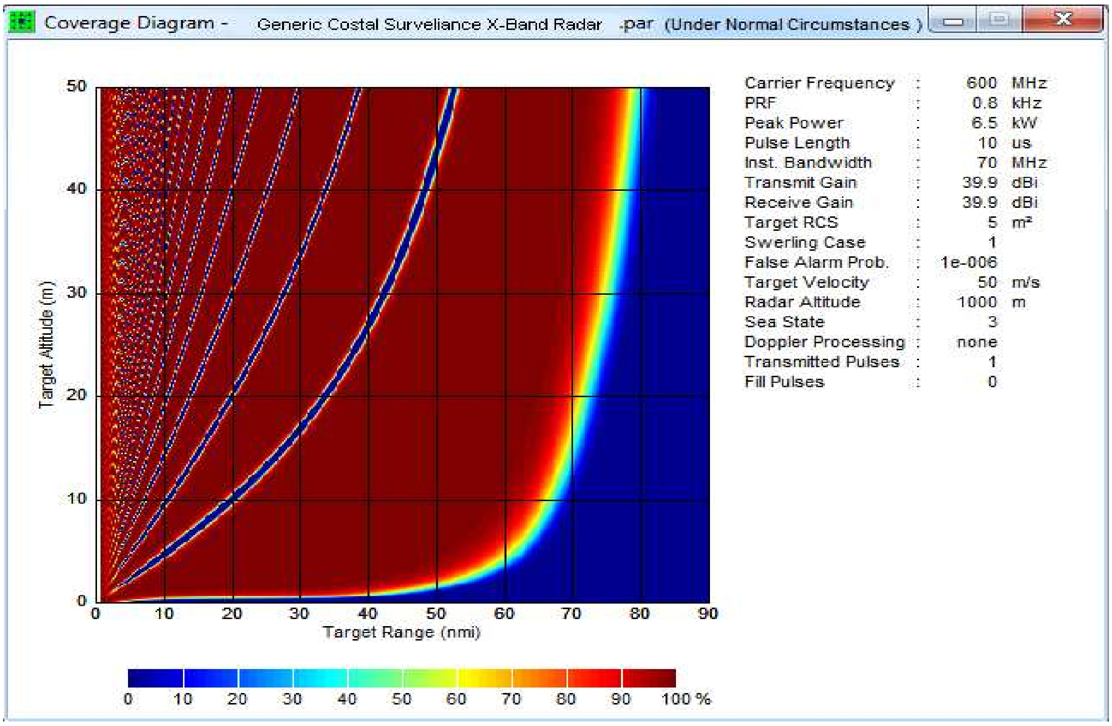

Figure 5.8 Coverage diagram of a generic coastal watcher X band radar at a radar altitude of 1000 meters

As shown in Figure 5.8, 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 sea surface. This result was obtained at an air temperature of 15 ^{o}C, under still wind and under a humidity of 70%. 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 5.9 shows the behavior of a Standard Maritime Surveillance Microwave Radar under Adverse Conditions.

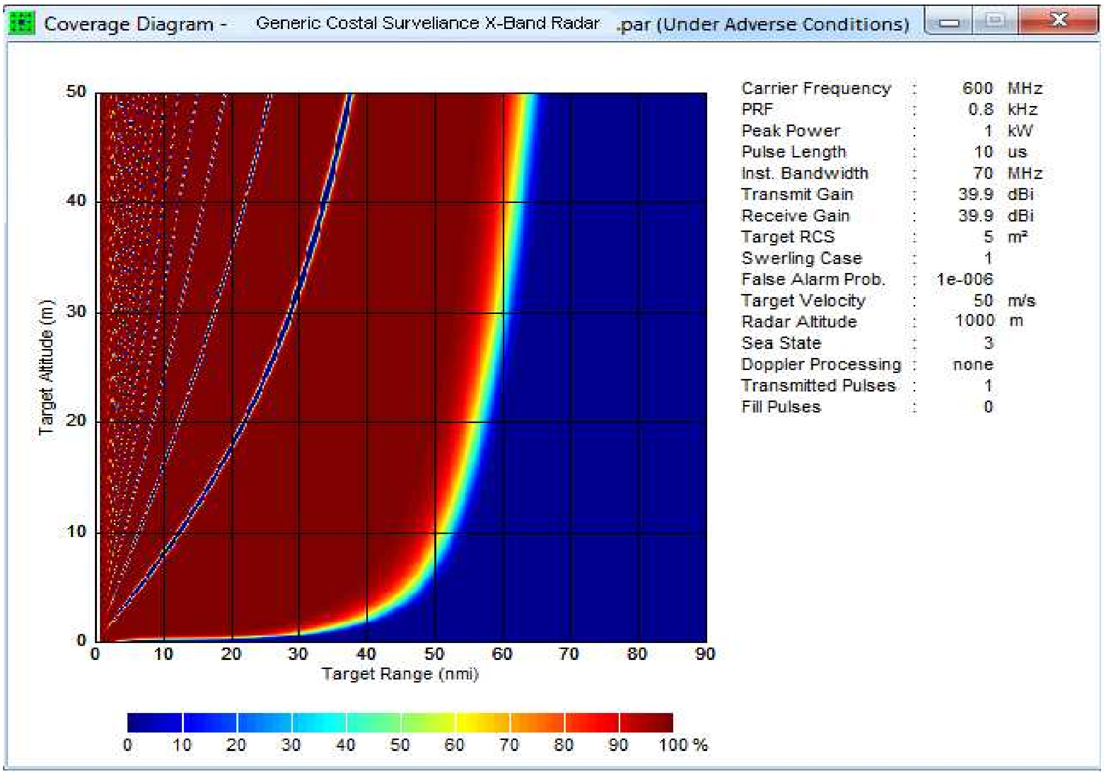

Figure 5.9 Coverage diagram of generic coastal watcher X band radar at a radar altitude of 1000 meters

As shown in Figure 5.9, the coverage of a Generic Coastal Watcher X Band Radar is approximately **50 nautical miles** at a an altitude of 1000 meters. In the scope of this study, the viewshed analyses under adverse conditions were performed based on a radar coverage of 50 nautical miles.

5.7 Viewshed Analysis of Territorial Waters

5.7.1 Viewshed Analysis of Territorial Waters under Normal Conditions

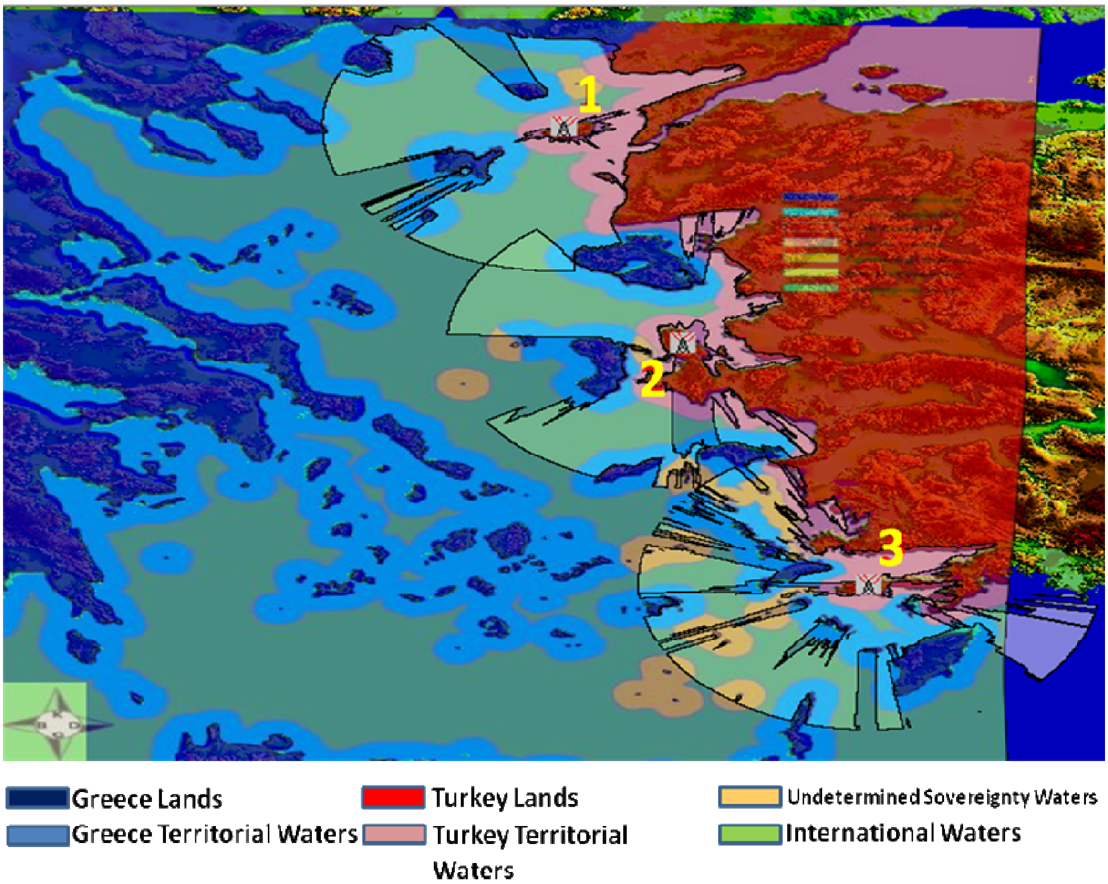

Figure 5.10 Viewshed analysis of territorial waters under normal conditions

As shown in Figure 5.8, a Generic Coastal Watcher Radar covers an area of 65 nautical miles at a radar altitude of 1000 meters. Figure 5.10 shows the viewshed analysis of the Turkish territorial waters carried out 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 5.10 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% covering the sea surface in a circle of 360 degrees. This indicates that all territorial waters of

Turkey and some part of 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 Izmir region to cover the middle Aegean Sea region. Radar 2 has a field of view of 36.8% covering the sea surface in a circle of 360 degrees. The cross-sectional area of Radar 2, covering Izmir Region and the middle Aegean Sea region, is lower compared to the north Aegean Sea region due to higher number of islands, islets, cliffs, and gulfs in the coverage area of Radar 2. This indicates that not all but a large part of territorial waters of Turkey 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 an altitude of 1145 meters in Marmaris region to cover the south Aegean Sea region. Radar 3 has a field of view of 45.5% covering the sea surface in a circle of 360 degrees. Radar 3, deployed at a lower altitude than Radar 2 and covering the east Mediterranean region and 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. This is due to the favorable position of Radar 3 and its deployment at a much higher point than the surrounding elevations. This indicates that almost all territorial waters of Turkey and high seas within the related region of interest are covered by Radar 3 with a coverage of 65 nautical miles under normal conditions.

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

5.7.2 Viewshed Analysis of Territorial Waters under Adverse Conditions

Figure 5.11 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 is not sufficient 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 5.11.

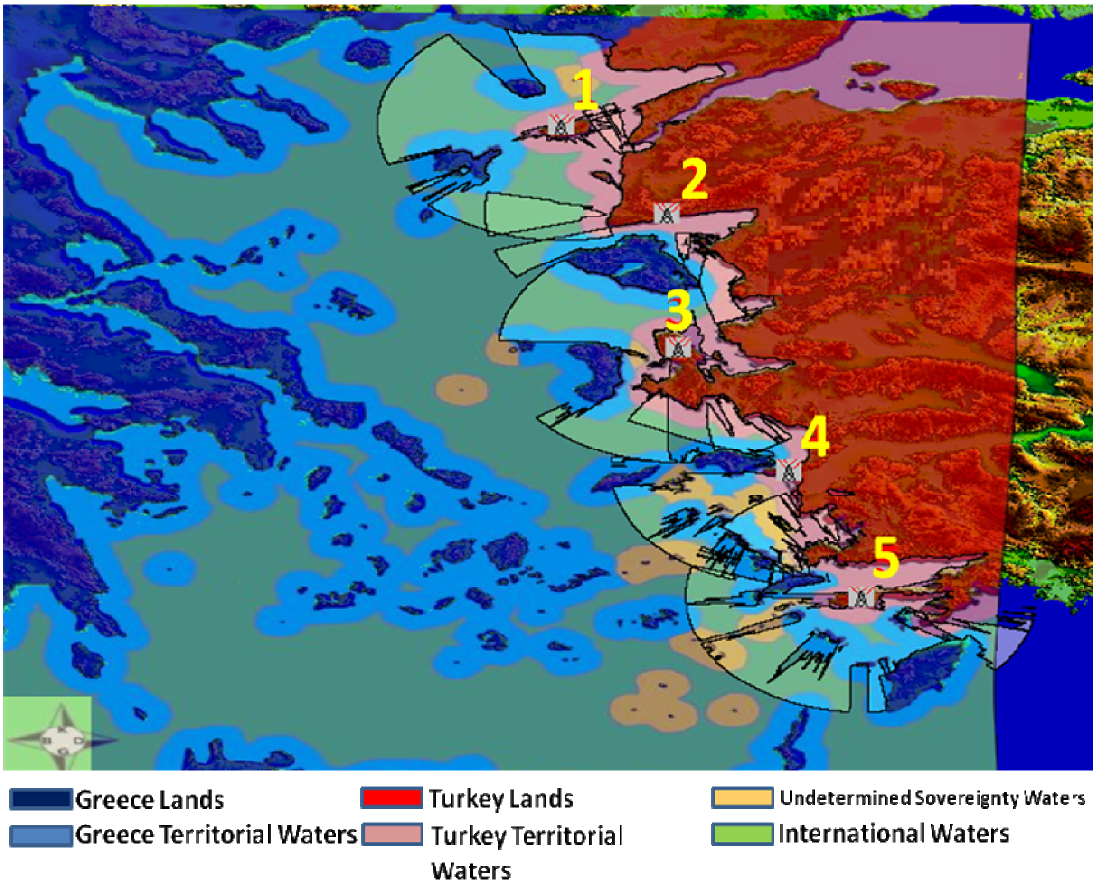

Figure 5.11 Viewshed analysis of territorial waters under adverse conditions

Radar 2, with an antenna height of 10 meters, was deployed at an altitude of 500 meters to cover the areas not covered by Radar 1 and 3 between the north Aegean Sea region and middle Aegean Sea region. In this intermediate area, Radar 2 has a field of view of 18.8% covering the sea surface in a circle of 360 degrees.

Radar 4, with an antenna height of 10 meters, was deployed at an altitude of 1185 meters to cover the areas not covered by Radar 3 and 5 between the middle Aegean Sea region and south Aegean Sea region. In this intermediate area, Radar 4 has a field of view of 33.6% covering the sea surface in a circle of 360 degrees.

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

5.8 Viewshed Analysis of Trade Routes of the Aegean Sea

5.8.1 Viewshed Analysis of Trade Routes of the Aegean Sea under Normal Conditions

The Aegean Sea is an area with heavy regional and international traffic between its ports and also on the route Black Sea-Mediterranean-Red Sea. Figure 5.12 shows busy trade routes and the coverage provided by three radars within a range of 65 nm under normal conditions.

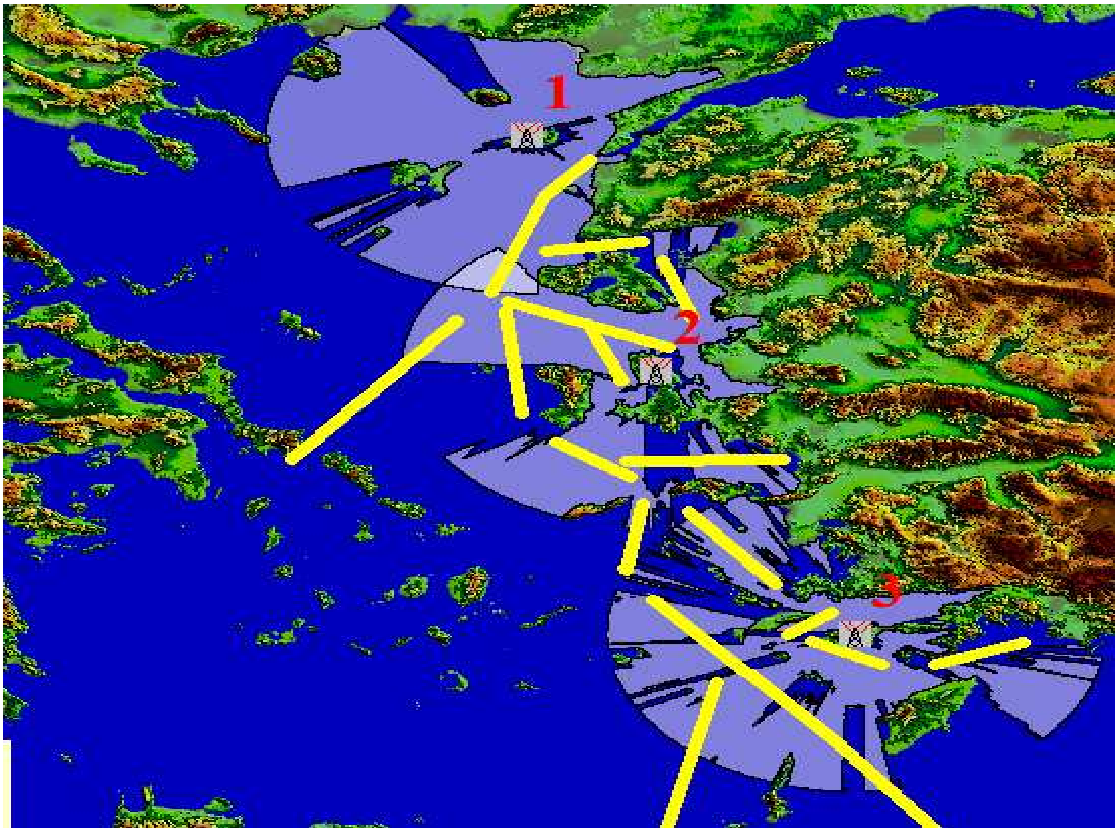

Figure 5.12 Viewshed analysis of busy trade routes under normal conditions

As shown in Figure 5.12, it can be concluded that a large part of busy trade routes are covered within a range of 65 nm under normal conditions and the ships navigating on the same route in those areas not covered will enter the area of coverage after a while.

Furthermore, Figure 5.13 shows viewshed analysis of passenger ship routes and the coverage provided by three radars. The viewshed analysis has revealed that almost all routes are covered.

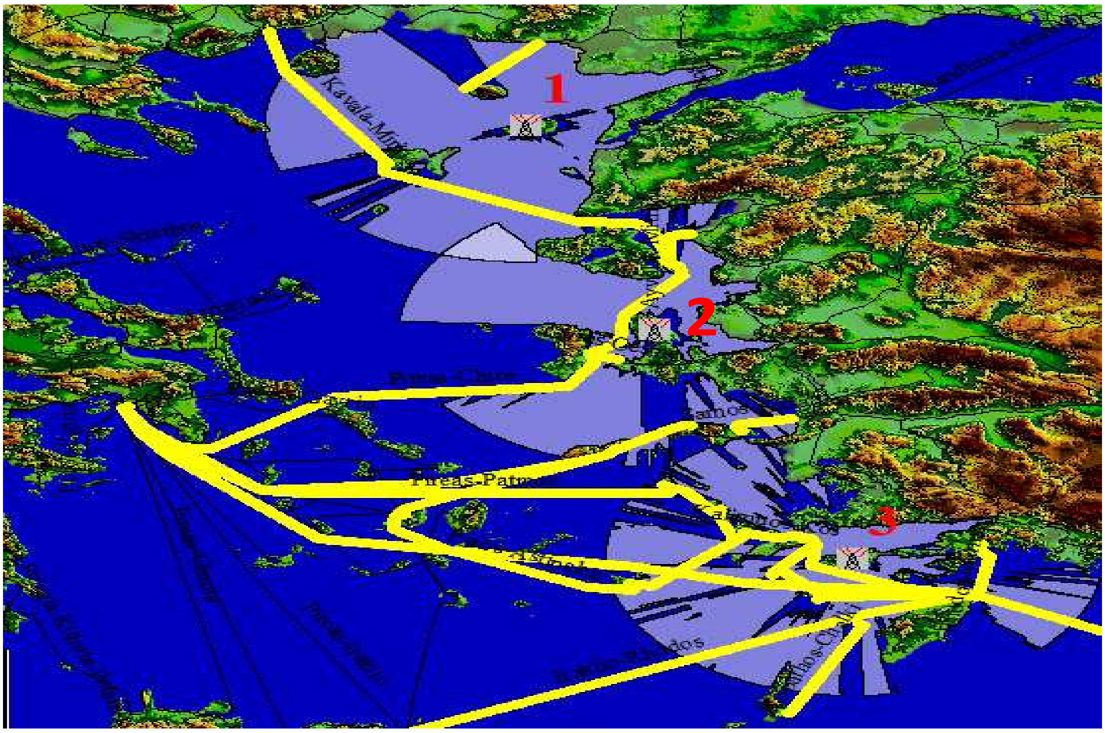

Figure 5.13 Viewshed analysis of passenger ship routes under adverse conditions

5.8.2 Viewshed Analysis of Trade Routes of the Aegean Sea under Adverse Conditions

Figure 5.14 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 is not sufficient to cover busy trade routes 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 5.14.

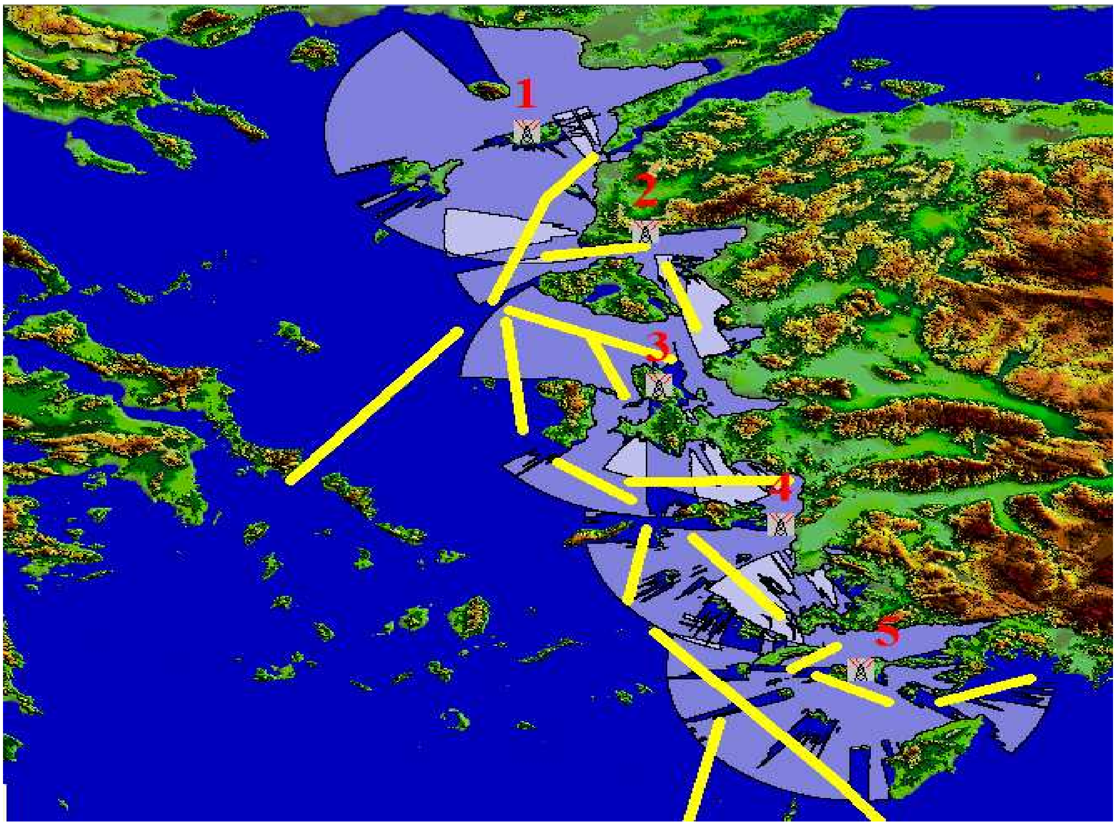

Figure 5.14 Viewshed Analysis of Busy Trade Routes under Adverse Conditions

Consequently, it is seen that a large part of busy trade routes are covered with the deployment of two additional radars. The analyses have shown that the ships navigating on the same route in those areas not covered by radars will enter the area of coverage after a while.

Furthermore, Figure 5.15 shows the viewshed analysis of passenger ship routes and the coverage provided by five radars within a range of 50 nm under adverse conditions. The viewshed analysis has revealed that almost all routes are covered.

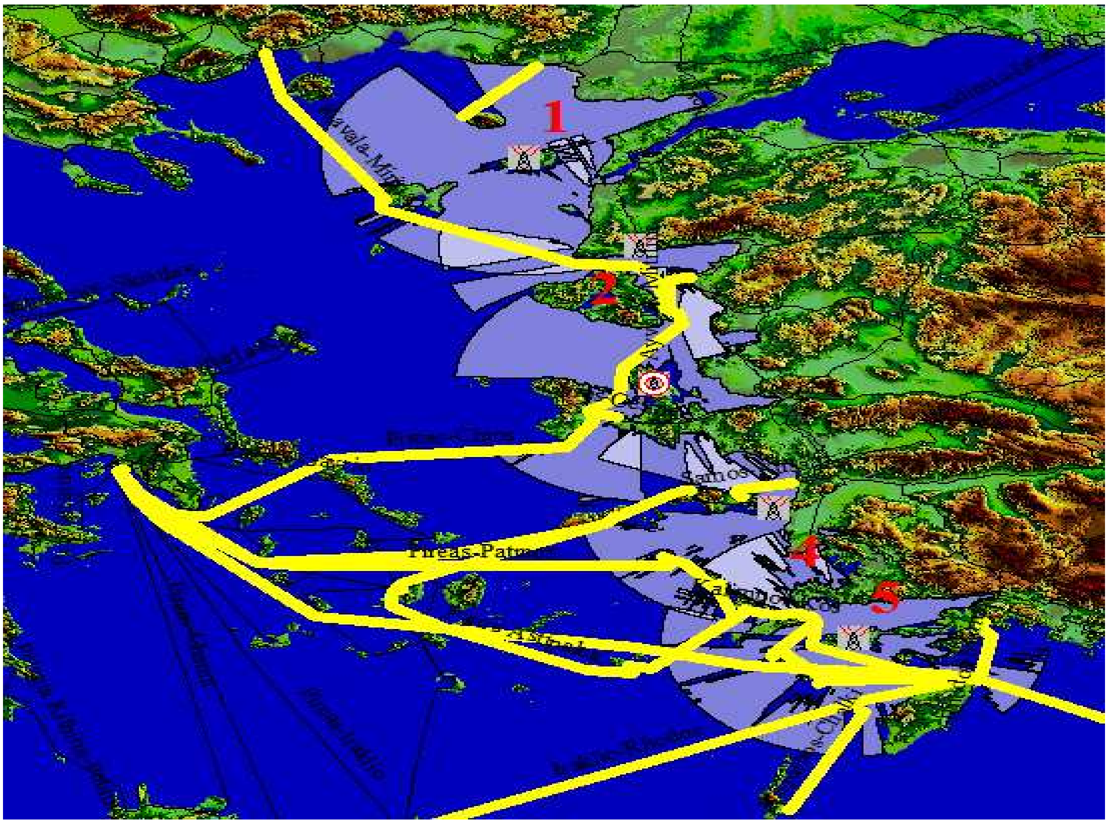

Figure 5.15 Viewshed analysis of passenger ship routes under adverse conditions

5.9 Viewshed Analysis of Search and Rescue Areas

5.9.1 Viewshed Analysis of a Search and Rescue Area under Normal Conditions

Turkey declared to IMO the coordinates of high seas over which Turkey could provide SAR services beyond its territorial waters. Figure 5.16 shows the line drawn based on the related coordinates. Figure 5.16 shows the viewshed analysis of a search and rescue (SAR) area where three radars providing a coverage of 65 nm under normal conditions are deployed to help SAR personnel in case of emergencies.

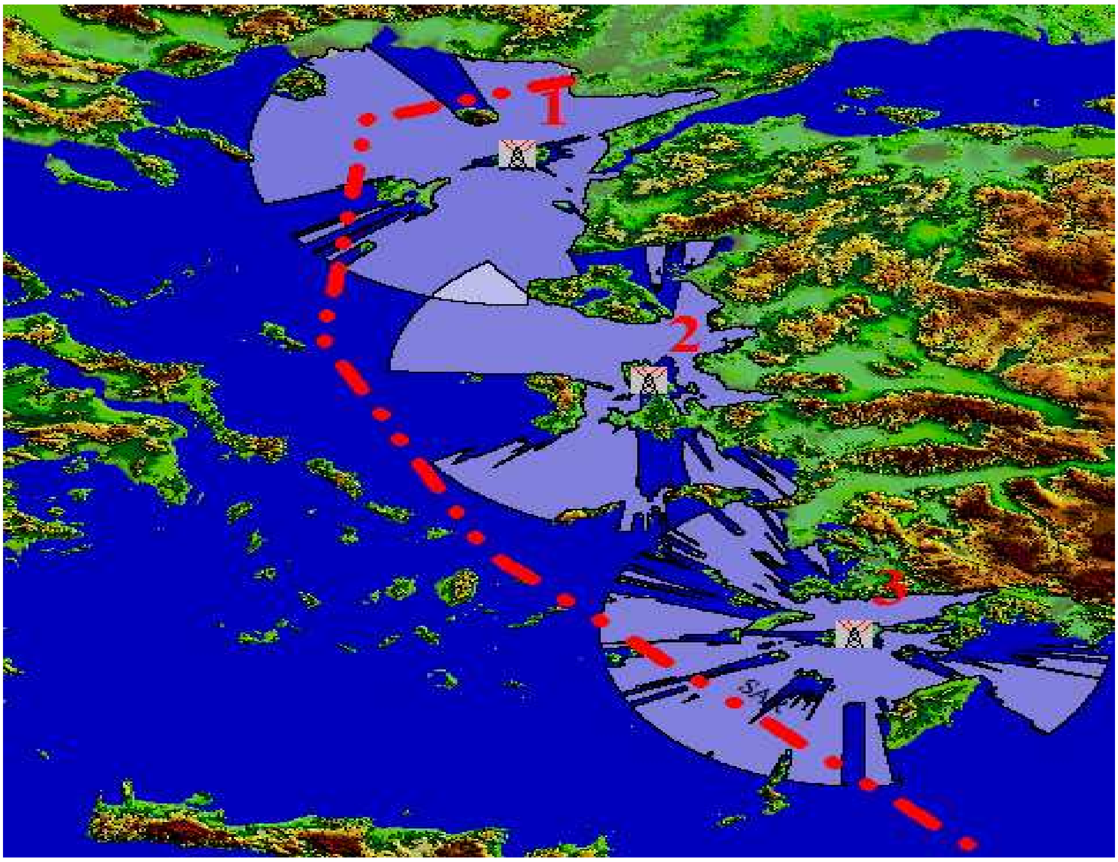

Figure 5.16 Viewshed analysis of a sar area of 65 nautical miles under normal conditions

As a result of the analysis, it is seen that almost the whole of the SAR area in the north Aegean Sea region and a great part of the SAR area in the middle Aegean Sea region are covered by radars. This is also the case in the south Aegean Sea region. It may be helpful to perform tracking by means of other information sources of the IMS system, such as LRIT and Cospas-Sarsat systems, for search and rescue operations in areas not covered by radars.

5.9.2 Viewshed Analysis of a Search and Rescue Area under Adverse Conditions

Figure 5.17 shows the viewshed analysis performed with the deployment of two additional radars providing a coverage of 50 nm, under adverse conditions, to help SAR personnel in case of emergencies.

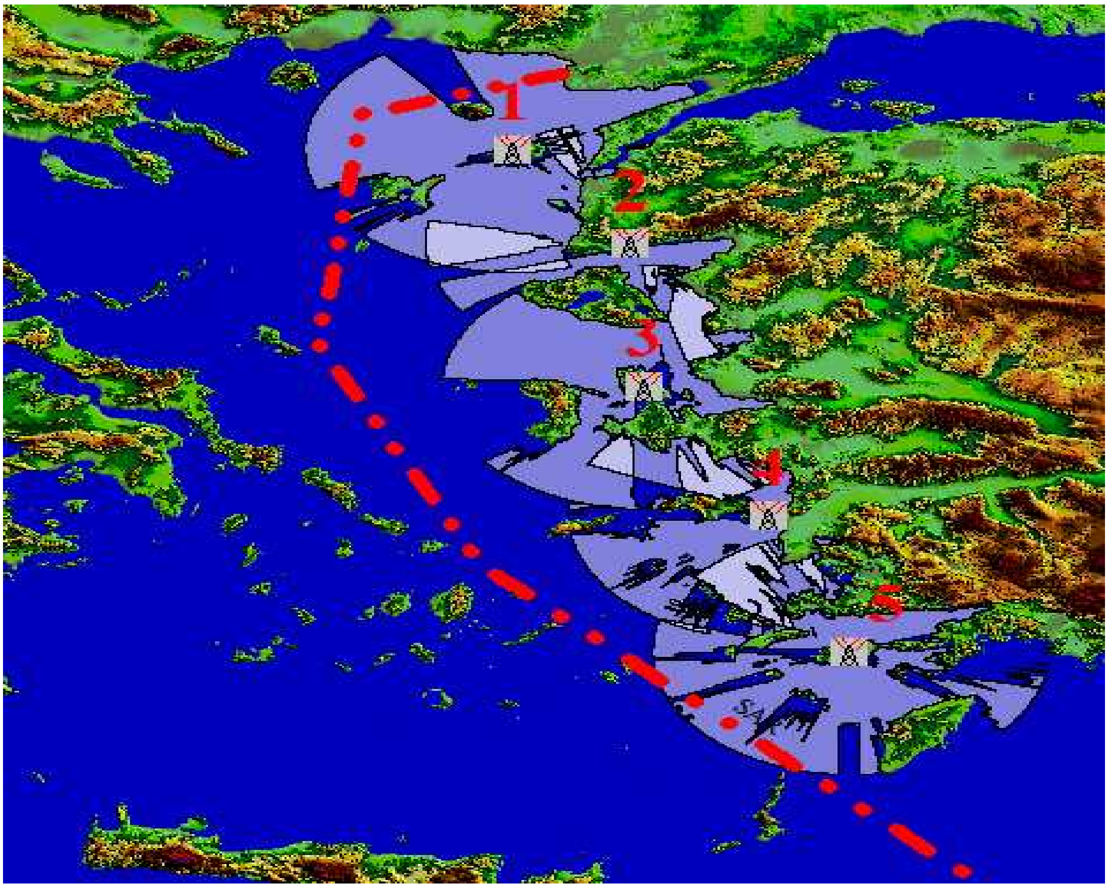

Figure 5.17 Viewshed analysis of a sar area of 65 nautical miles under adverse conditions

As a result of the analysis, it is seen that almost all areas within a range of 50 nm from radars are covered with the deployment of two additional radars. However, especially in the middle Aegean Sea region, an area of 45-50 km beyond the coverage of radars cannot be covered. It may be helpful to perform tracking by means of other information sources of the IMS system, such as LRIT and Cospas-Sarsat systems, for search and rescue operations in areas not covered by radars.

CHAPTER SIX
CONCLUSION

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

Due to such reasons, the construction of a recognized maritime picture, which enables to monitor commercial traffic in the territorial waters of Turkey, 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 IMS system. The primary objective of IMS system is to construct a recognized maritime picture.

In order to build a comprehensive maritime trade picture, the required number and deployment locations of radars, one of the most important 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 with the deployment of microwave radars, whose coverage is limited to the horizon line, at the highest possible point. However, numerous attempts of deployment in the scope of this study has 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 Turkey and international transit routes within the respective region of interest. Maritime control is maintained meticulously thanks to the high resolution of X-Band radars. Moreover, a system backup can be maintained using Mobile X-Band radars for situations such as war, disaster etc. The desired focus can be provided thanks to Mobile X-Band radars and the outputs can be evaluated within the scope of the IMS system. 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 other information sources, such as LRIT and COSPAS-SARSAT, are required in order to cover more extensive regions such as search and rescue areas. Furthermore, it is shown that the recognized maritime picture will represent meaningful data when combined with target detections and tracks derived from radars.

It is evaluated that more precise analyses may be conducted in case of the use of DTED Level 2 and DTED Level 3 maps, which are more precise than DTED Level 1 maps used in our analyses.

Finally, the Aegean Sea, having different features with regard to geographical difficulties and diversities, has been chosen as the subject of our study and a methodology has been developed for the correct deployment of radars, as one of the major components of the IMS system, has been developed. Also, the applicability of this methodology other regions is being evaluated.

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