

Chapter 2

Improving Situation Awareness in the Maritime Domain

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2.1 Introduction

Organizations in the maritime safety and security domain have to cope with complex situations at sea, harbors, and rivers to maintain acceptable levels for safety and security. For safety, traffic rules apply at sea. Yet in areas with heavy traffic, it is difficult to tell which vessels adhere to traffic rules and which ones do not. For security, suspicious activities such as drugs smuggling need to be detected. In the past years it has become clear that there now are more means to detect vessels, because more vessels have equipment to broadcast their current position or are detected by sensor systems that are placed along the coast. At the same time, the rising problem is that it has become difficult to handle complex situations because of the amount of vessel movements in an area. In addition to the more complex view on vessel movement, more information on vessels is available in databases and on the Internet. To identify a vessel as suspect, information about the crew, cargo and owner can be used as a discriminator. Today's maritime safety and security systems do not provide the mechanisms to handle the amount and diversity of information that is available. It is the task of operators to combine all information and elicit suspicious vessels. The risk is that operators have an information overload which causes them to miss important and relevant events, or to notice them too late. In this chapter we discuss several scenarios that indicate difficulties that maritime safety and security organizations face while building situation awareness.

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2.1.1 *Situation Awareness*

Maritime safety and security organizations build situation awareness of the area they control and monitor. Situation awareness, see also Chap. 1, Sect. 1.2, is defined in [4] as:

The perception of environmental elements with respect to time and/or space, the comprehension of their meaning, and the projection of their status after some variable has changed, such as time.

In this definition examples of environmental elements in the maritime domain are vessels and oil-rigs. Also, areas with stormy weather or with an oil spill are environmental elements.

Situation awareness involves building the awareness in an area and associating information with objects in that area. If an incident happens, all information is available and decisions can be taken to cope with it. Situation awareness applies to several domains, see Sect. 1.2, and the characteristics that these domains have in common are:

- The high diversity of information,
- The large amount of information, and
- Real-time streaming (high flow rate) of information.

The complexity of the information stream is further increased since there are usually more information sources to be considered. There is also criticality associated to the domain. A poor decision because of bad situation awareness may result in a catastrophic impact.

Building and having up-to-date situation awareness where there is a complex information stream is almost impossible to do for decision makers without the help of a system. The purpose of such systems is foremost to structure the information such that operators do not suffer from an information overload.

2.1.2 *State-of-the-Art in Maritime Safety and Security Systems for Situation Awareness*

Maritime safety and security organizations become increasingly aware of the heaviness of the traffic in an area. In this book, the traffic along the Dutch coast is used as an example case. The North Sea is one of the areas with the heaviest traffic in the world. This increases the complexity of information streams to handle. The complexity in handling traffic is further increased by the following:

- Smaller vessels have to report their position nowadays which results in an increase in the amount of vessels and in information on the position of these vessels;
- More accurate information on the type of vessel and its cargo is available;

- A trend that can be observed in the past years is that vessels become larger, which implies that if such a large vessel is involved in an incident, the (catastrophic) impact will also be larger.

The monitor and control systems that these organizations currently use cannot cope with the amount of information that is available. At this moment, the majority of information sources must be interpreted by operators, or is simply ignored.

2.1.3 Challenges in the Maritime Safety and Security Domain

Maritime safety and security organizations face at least the following two challenges in building situation awareness.

- The first challenge is gathering information on vessels in general, and more specifically on vessels that act strange, or can potentially harm others because of course and speed. Sensor data must be combined with information from closed or public information sources to elicit suspicious vessels. The amount of extra information from these sources can easily result in an overload. It is often quite cumbersome to relate information from information sources with sensor data. Today's maritime safety and security systems do not provide sophisticated interaction mechanisms to deal with the diversity of information. Here, examples of closed information are cargo manifests and the organization's own information of a vessel. Public information sources include web pages on the owner of a vessel and social pages of crews.
- The second challenge is identifying critical situations. It is not trivial to see what is critical in the normal. The increased complexity by the number of moving objects and the amount of information that can be associated with an object, makes it difficult to notice and act on incidents. It also makes it more difficult to keep performing routine work while incidents happen. There exists a huge variety in how incidents happen. Incidents can be unintended or intended,¹ may involve various (types of) vessels, can happen in any weather condition, etc. The maritime safety and security systems that are available at this moment are quite limited in alerting operators on critical situations.

Building accurate situation awareness is becoming more and more the result of multiple organizations that work together. There is collaboration with affiliated organizations (national and international) to trace vessels that are potentially dangerous. This also puts additional requirements on information exchange between organizations. Not all information can be shared because of confidentiality constraints. It may even be that information is not shared unless there is an incident where it is essential to have additional information because of increased risks.

¹Unintended incidents are safety incidents. Examples of intended incidents are smuggling and terrorist acts.

These challenges and the limited capabilities of maritime safety and security systems give maritime safety and security organizations that work on building situation awareness a difficult task. It forces them to intensively study information they receive and watch vessel movements. This results in strain and possible fatigue. The resulting loss of attention may lead to missing of events. These challenges were discussed with experts in the field, and they are further refined throughout the chapters of this book.

Maritime safety and security organizations are often government organizations that have to deal with equal or shrinking budgets while their tasks become more complicated. To cope with this, organizations need to streamline their activities and become more efficient. The goal of this chapter is to point out what type of characteristics a maritime safety and security system should have to help streamlining activities and make operators more efficient.

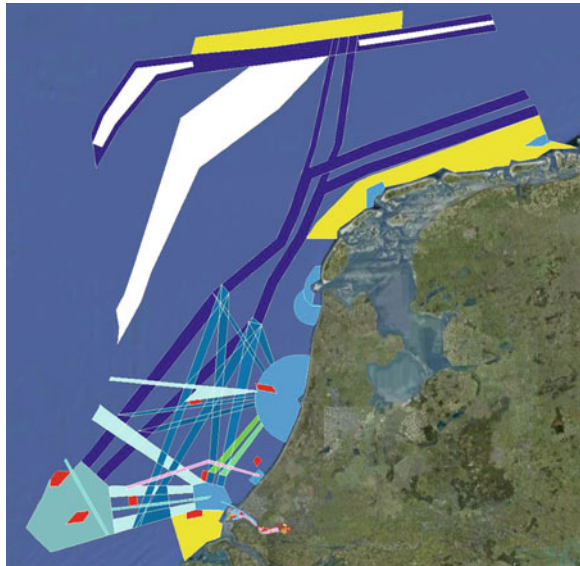
In the next section we explain the difficulties that organizations face to build situation awareness. In Sect. 2.3 we make a case that it is essential to cross-link information from several information sources to build good situation awareness. Section 2.4 discusses several scenarios that can be seen as illustrative for the type of problems organizations face. Section 2.5 discusses how maritime safety and security organizations' tasks can be alleviated and where a system can be of assistance.

2.2 Building Situation Awareness

Maritime Safety and Security (MSS) organizations have to make a considerable effort to build situation awareness of an area by using the current generation of monitoring and control systems. Building situation awareness of the Rotterdam area, let alone the Dutch coast is quite complex. In 2007 on a daily basis there were about 1,500 vessels that transmit their position by using the Automatic Identification System (AIS; see Sect. 1.5.1). AIS transmits a number of times per minute data of a vessel that contains the position of the vessel, its destination, etc. Of these vessels the majority crosses or is in the neighborhood of the Rotterdam area. On a yearly basis there are more than 500,000 vessel movements that are reported by AIS. Larger vessels are obliged to transmit their position by using AIS transponders. However, small vessels at sea often do not carry AIS transponders, so the amount of traffic is in reality larger. From the budget that is assigned to the Dutch coast guard and from experts we know that the number of vessel movements is relatively stable, and that the vessels themselves get larger. The number of vessels that report their position by using the AIS is also growing. By law, in coming years smaller vessels also have to carry AIS transponders.

Besides moving objects, there are also a number of static objects in the North sea. There are over 300 oil and gas platforms, and a dozen windmill parks.

Fig. 2.1 Sea lanes in front of the Dutch coast, shown as a layer in Google Earth (©2011 Google)



2.2.1 Traffic Separation Scheme Along the Dutch Coast

To control the traffic along the coast, a number of laws are applicable. The goal of these laws is to keep the amount of incidents and their impact as low as possible. For example, traffic with dangerous cargo, such as chemicals and oil, must stay clear from nature preservation areas such as the Waddenzee. The Dutch government organization Rijkswaterstaat² defined a so-called Traffic Separation Scheme. The Traffic Separation Scheme aims at regulating the traffic at sea in so-called sea lanes. Figure 2.1 shows the Traffic Separation Scheme before the Dutch coast.

In Fig. 2.1, the Dutch coast is clearly recognizable. The colored areas in the figure visualize the Traffic Separation Scheme. The red areas denote anchor areas. These are used by vessels to hold a position before they can go to the harbor to release their cargo. The yellow areas mark restricted areas. Large cargo ships, tankers, etc. are not supposed to be in these areas. The other, mostly blue shaded, areas represent clear ways and sea lanes that vessels use. In the remainder of this section the term sea lane is used. Note that the colors of the areas and sea lanes are only used to differentiate the different areas and sea lanes.

Sailing between the lanes is not prohibited, but may result in dangerous situations. Needless to say that the amount of vessel movement and the sailing between

²<http://www.rijkswaterstaat.nl/>

the lanes is not beneficial for building good situation awareness. Larger vessels that follow the sea lanes often follow a plan and their movement can be predicted. Smaller vessels usually just go from A to B which can be confusing for operators.

2.2.2 *Necessity of Building Situation Awareness*

One year of AIS data before the Dutch coast was analyzed by POSEIDON. In this data set, several examples were found where vessels:

- Cross or closely pass wind-mill parks or oil-rigs that are present in the North-sea,
- Start to drift,³
- Suddenly deviate from their course so collisions with another object (vessel or oil-rig) may occur, or may not occur in case of evasive maneuverings,
- Sail against the traffic,
- Pass restricted areas (such as nature preservation areas) at too close distance while carrying dangerous cargo.

These are all examples that show that a close monitoring and control of traffic at sea is essential. To do this, situation awareness must be built.

Situation awareness that MSS organizations currently build is shown in Fig. 2.2. This figure shows the vessel movements in the North-sea around the Waddenzee area [3]. The purple lines and areas mark the waterway system that exists in the Dutch waters. The arrows in the map indicate the sailing direction of vessels. The labeled boat-shaped figures mark vessels, the labels of these figure are vessel names, and the squares mark the oil-rigs in the area.

It takes some experience to know the vessel movement in an area. If vessel movement is captured at all, it is at this moment not used by MSS organizations for play-back purposes to learn from historical vessel movement. MSS organizations need to learn patterns in vessel movement, behavior that can be associated to types of vessels, etc. Being knowledgeable on patterns of vessels and behavior that can be associated to types of vessels helps in identifying and preventing incidents. Organizations also need to be knowledgeable on differences in behavior of vessels that are caused by the environment, for example:

- Behavior of maintenance boats in wind parks,
- Coast guard ships leaving ports when heavy weather is expected,
- Seasonal fishing patterns,
- Reaction of commercial shipping to heavy weather,
- Pilot boats delivering a pilot to an incoming ship.

³Drifting is when a vessel does not have engine power, cannot be steered and is going with the waves and wind

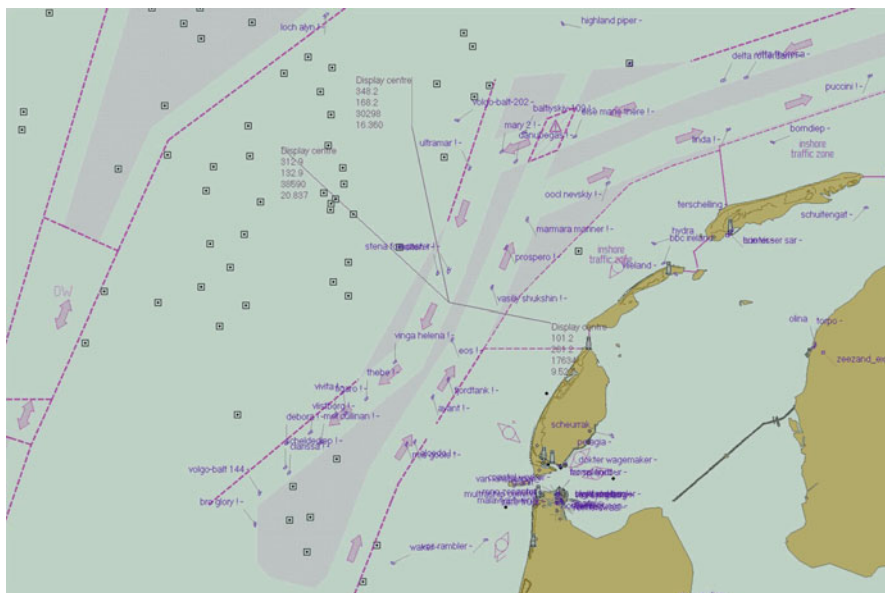


Fig. 2.2 Screen shot of the Netherlands Coastguard system in the Operations Centre in Den Helder [3]

The difficulties operators of these organizations face is that beside interpreting the geo-spatial information of vessel movement, they nowadays also have to combine this information with information about the owner, flag, and even news items in which a vessel is mentioned. Using only geo-spatial information usually does not reveal vessels that have a higher risk profile or that are involved in illegal activities such as smuggling, environment pollution, piracy. With the availability of AIS, improved in-house information systems and the Internet more information on vessels is available to determine the risk profile of a vessel. However, combining different information sources is a time consuming task and can result in an information overload. Another approach can be to simply visit every vessel at sea and investigate it. This is a very time consuming approach. On average, a vessel visit with investigation takes a few hours. Since not all vessels can be visited at sea, it comes to the experience of individual operators to find suspect vessels.

2.2.3 Dealing with a Reduced Sensor Network to Build Situation Awareness

To monitor large areas such as the Dutch coast, a relatively large number of sensors is needed. Along the Dutch coast there are several radar stations and AIS base stations that detect and pick up data from vessels. This data is combined and

transmitted to the center of an MSS organization. Since the number of sensors is relatively large, it is possible that one or more sensors produce data with less quality than normal. The result of data quality loss is usually that an area cannot be monitored or can be monitored less well. A reduction in the quality can imply that a sensor is not functioning, or that the weather conditions in the area prohibit a good transmission of signals. To increase the quality, a measure can be to send out a ship or an airplane for investigation, or to deploy a mobile station. Here, mobile means that base stations are situated on coast guard vessels, or airplanes. In other words, the network of AIS and radar stations is extensible and reconfigurable.

2.3 Combining Information

Operators need to interpret and reason on a lot of information to make the correct decision. The military domain already recognized this problem and defined a process to cope with it. This process is coined the OODA loop: Observe, Orient, Decide and Act [2].

2.3.1 *Observe, Orient, Decide and Act*

Organizations that provide monitoring and control services often adopted the OODA loop. The OODA loop guides operators on the decision making process, and on using available information. The OODA loop has its origin in military command and control systems, but was also adapted for civil systems. Figure 2.3 shows the process.

The process has the following steps:

- Observe: know what is happening.
- Orient: understand the meaning of what was observed.
- Decide: weighing the options available and picking one.
- Act: carrying out the decision.

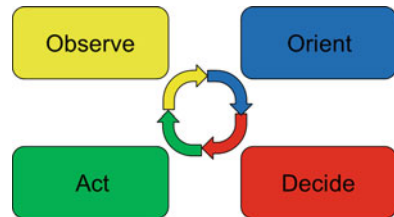


Fig. 2.3 The OODA loop

Following the OODA loop in itself is not possible if information is not combined. Combining information from multiple sources implies that operators need to interpret and reason upon the information.

2.3.2 *Interpreting and Reasoning on a Situation*

What operators do, and what the OODA loop describes is that operators use data from sensors and domain knowledge to interpret and reason on a situation. This happens at the beginning of the loop, and starts again after a decision has been made and an action has been taken. Figure 2.4 illustrates this.

In Fig. 2.4, the triangles represent (on a high level) the knowledge and information sources where operators have access to, and his abilities. The arrows indicate how the sources are used by operators. The blue triangle represents domain knowledge. Here, domain knowledge can be the experience of operators, or the information that an operator retrieves from the organization's MSS systems. Operators need to be creative to apply the domain knowledge to a situation. The red triangle represents the reasoning ability of an operator to make this mapping. The green triangle represents the data of a situation that is picked up by sensors and that must be interpreted by operators, or that operators retrieve from the Internet or other sources. The green triangle also represents the result of the interpretation, as is explained below.

When an operator starts interpreting or reasoning on a situation, sensor data is likely to be the most informative input. After having added more domain knowledge and having reasoned on the situation, the sensor data becomes less important, and the domain knowledge and reasoning ability of operators more important. Figure 2.5 illustrates this reasoning, combining and abstracting of information.

In Fig. 2.5, in the background the three above mentioned triangles can be recognized. The arrows indicate the flow in which operators reason and combine. The arrows form a spiral that goes from bottom to top. The spiral crosses several levels of reasoning and combining. These levels are separated by horizontal lines.

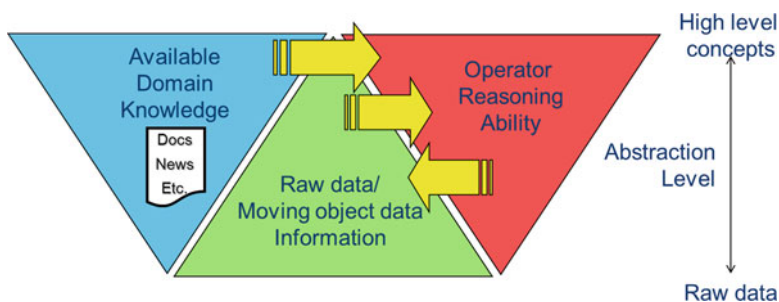


Fig. 2.4 Combining raw data, knowledge and reasoning ability

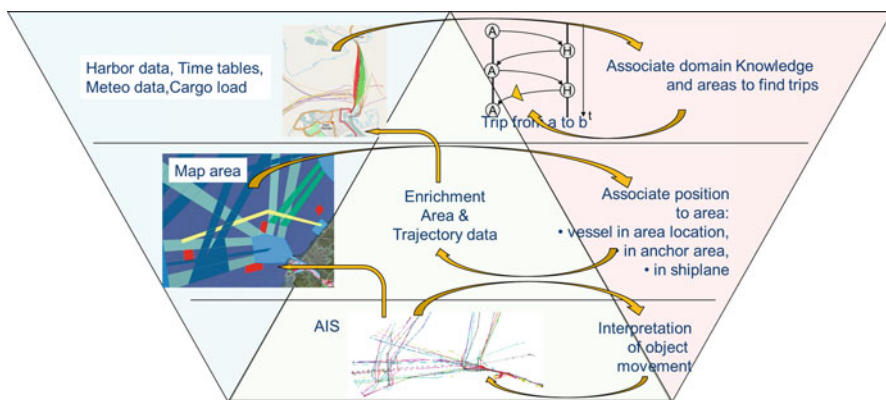


Fig. 2.5 Abstractions in reasoning

To solve a question three levels of reasoning and combining were needed. Other questions may take fewer or more reasoning levels. The question that is solved in the figure is: “is the position and movement, and timing of a vessel according to a scheme”. Here, scheme means that the vessel is using the sea lanes that it is supposed to use, and that it is moving at an expected moment of the day. At the lowest level, operators interpret the AIS data that is received by sensors and that is visualized by the MSS system of the coast guard. The operator searches for behavior in the movement of objects that cannot be understood without further investigation. To make the object movement better interpretable, the image is enriched with map data of different forms. This map data can include data about sea lanes, ship wreckages, weather information, seasonal effects on fishing behavior, etc. By doing so, it becomes easier for operators to associate the position of objects in an area. Through the association, a meaning can be linked to the position. For example, the operator knows the vessel is in an anchor area. The object movement can be further explained by arrival and departure data from harbors, time tables of daily trips, maintenance schedules of oil-rigs, meteo data, the cargo of a vessel or by radioing the vessel. By using this information the operator can deduce that the vessel needs to take another, less economic route to its destination because of its dangerous cargo, or that a vessel follows a time-table.

Figure 2.5 also shows that the type of information that an operator has to handle has large diversity and can vary per scenario. To illustrate the reasoning and combining of information together with the OODA loop, the following example is used:

Observe: Operators are observing the traffic before the Dutch coast. This is done by watching visualizations of AIS messages on screen, and listening to radio traffic and reading Internet sites with blog data of the area.

Orient: A vessel that is sailing in a sea lane suddenly deviates from the lane. This in itself is not abnormal behavior. However, it is now headed for an oil-rig.

According to the AIS messages that are sent by the vessel, it is a so-called Special craft. Special crafts are a rather broad class of maritime investigation vessels or maintenance vessels. In this case, it can mean that the vessel is a maintenance vessel that is going to do repair activities, or that is delivering goods to the oil-rig. If the vessel is not doing maintenance activities, then it should not be in the neighborhood of the oil-rig. The vessel movement is projected on a map of the area. Vessels that deviate from a sea lane can be found more easily this way. Also, vessels heading for static objects such as oil-rigs can be identified more easily. The additional information in the AIS messages of the vessel gives the operator additional information to reason on and to further enrich the data. In this particular case, the operator starts to search if the vessel is a maintenance vessel of some sort.

Decide: In general, vessels must keep a distance of about half a nautical mile from static objects or other vessels. This is to prevent incidents. For example, if the vessel becomes “not under command” for some reason or suddenly deviates from its course, it may hit an oil-rig and cause an environmental disaster. If the vessel is a maintenance vessel, it should be mentioned on a short list. The operator decides to check if this is the case. By using time-table type-of data in combination with information on maintenance vessels in the area, information is cross-linked and the operator can determine whether the vessel is a maintenance vessel. Since the vessel is not in the list of vessels that is the result of the cross-link, more information is needed. There are multiple ways of getting this information.

Act: The suspicious vessel is not listed as a maintenance vessel and the operator decides to radio the vessel to ask its intentions and to find more information on the vessel. The operator asks the vessel and enriches the result of the conversation with the available information.

Observe: The result of the radio call is that the vessel reports they are hired by the owner of the oil-rig to do under water maintenance. So the operator starts to gather additional information on the vessel itself.

Orient: A quick search in the coast guard’s MSS system learns that the vessel is a special craft that is equipped with under water repair equipment for oil-rigs. The found characteristics of the vessel is combined with the available information.

Decide: The operator is satisfied and decides that further checking is not needed.

2.4 Typical Scenarios

MSS organizations have their specific tasks. The type of incidents that are watched for differ per organization. In this section we discuss typical incidents such as detecting traffic rule violations, performing search and rescue actions, and finding vessels that act suspiciously. Where applicable, in the scenarios we point out the crucial/vital information that leads to a decision.

2.4.1 *Strange Behavior*

Strange behavior is mostly related to kinematic data (course, speed, position) of vessels. The movement data is picked up by sensors. Operators are looking for unwanted, suspicious, or illegal movements of vessels and interactions between vessels. Characteristics to identify incidents are:

- Speed of movement:
 - Absolute speed is larger than 25 knots in open sea
 - Loitering or hovering in an area
 - Sudden increase or decrease of the speed
 - Type of vessel in relation to its speed
- Direction of movement:
 - Making 180° or 360° turns
 - Sailing against traffic
 - Sailing through anchor areas
 - Unusually large number of course changes
- Vessels outside the historic behavior
- Unknown origin and/or destination of vessels
- Vessels that are drifting:

Vessels at drift are vessels that are not under control. This may occur because the engine breaks down or the bridge is not under command. Drifting vessels may cause a lot of problems if they collide with other vessels or obstacles at sea such as oil-rigs.

Watching for the above type of behavior is a way for operators to focus on vessels that are more likely to be involved in incidents.

2.4.2 *Search and Rescue Operations*

Another type of activities in which operators have to assist are search and rescue actions. To aid rescuers, operators search for background information on vessels that are involved in the incident. We illustrate this type of action by using a scenario in which a vessel is involved in a clandestine operation and gets into trouble in front of the Dutch coast. Note that the scenario itself is fiction, but consists of elements that have happened in practice.

An Italian navy vessel is patrolling in the Somalia area. The vessel is patrolling in the area as part of the NATO operation Atalanta. The vessel observes through its sensors that two vessels have an interaction. The Italian navy vessel requests information from other vessels in the operation Atalanta if more is known about the vessel and if an interception is needed.

The request is handled by a vessel of the Danish navy and it passes general information about the questioned vessel to the Italian vessel. Details about the cargo are not shared. Additionally, the Danish vessel announces that the vessel is not to be intercepted. Although not shared, this is because the Danish navy and the Danish police are involved in a joint operation where they are monitoring clandestine operations. The Danish police has infiltrated and wants to see the course in which the clandestine operation evolves. The vessel that is involved in the clandestine operation is headed for the Danish capital Copenhagen. The vessel has to pass the Dutch coast.

Before the Dutch coast the vessel that is involved in the clandestine operation gets into trouble. It has had a collision with another vessel in stormy weather. The incident happens in a sea lane. Both vessels are in need and send a distress signal. Operators of the Dutch coast guard are monitoring the sea. They receive the distress signal and try to establish communication with the vessels to get more details on the situation on board. The AIS data that is picked up by the Dutch coast guard contains the identity of the vessels. Other information that is transmitted through AIS and that is relevant in this case is the type of vessel, whether the cargo is dangerous or not, the size of the vessel, and its destination. The coast guard asks vessels in the neighborhood to be aware of the incident and that it may result in dangerous situations. Since the vessels are powerless, they start to drift. The coast guard sends out a helicopter to get more information on the incident. The result of these actions is that a search and rescue operation must be set up.⁴

Since the coast guard wants to have as much information as possible to better structure the search and rescue, it asks affiliated organizations if they have more information on the vessel that is important for a search and rescue activity. The Dutch coast guard passes a request to Northwood in the UK from which the operation *Atalanta* is controlled and monitored to learn if more is known about the vessel. Northwood passes all information it has on the vessel that is involved in the clandestine operation. Through this information the Dutch coast guard finds out that the cargo contains Anthrax, which was meant to be distributed to terrorist cells in Europe via Denmark. The rescuers must use protective clothes and other vessels must keep a safe distance of at least 1,000m. Vessels that are within the 1,000m or are on a projected course in which they cross the Search and Rescue area must be notified to not enter the area or to leave the area. The coast guard approaches all relevant vessels individually to take the necessary actions.

2.4.3 Drug Trafficking

Drugs trafficking in general is difficult to detect. Vessels involved in such activities try to behave as normal as possible to avoid drawing attention. Also in Dutch waters,

⁴Note that the OODA loop is used here.

drug trafficking takes place. Getting the drugs into the country can happen in several ways. The vessel with the drugs can just sail into the harbor and release its cargo. Harbor authorities should be aware of this type of incident and act on it. Operators of the coast guard can be supported by finding background data of the vessel and determine the chances of it being involved in illegal activities. Other ways are to have rendezvous at open sea, package droppings (a vessel drops a package in sea that is picked up by another vessel), or very quickly go to shore, drop a package and get out again before authorities can respond.

The following scenario illustrates a rendezvous of vessels. Note that the scenario itself is fictional, but consists of elements that have happened in practice.

It is commonly known that fishing trailers are at sea for larger periods of time, and go to distant seas to catch fish. In this case a relatively small fishing trailer heads to the horn of Africa to pick up a drugs transport and bring it to Europe.

The vessel approaches the Dutch coast from the south. North-west of Texel, 5 miles out of the coast, the trailer deviates from the regular sea lane and decreases its speed to come to a full stop. At that time several vessels rendezvous with the trailer to transfer the drugs. After some time they depart again. The trailer carries on and the sailing vessels head back to the harbor to bring in the drugs.

Is it difficult to detect rendezvous at open sea. There are a number of reasons: the incident happens in a relatively short time frame, vessels do stop at sea, the incident may happen just out of reach of vessels that can respond. Catching the drugs traffickers on shore is usually difficult since it is mostly done at night, and the dunes offer sufficient protection.

2.4.4 Smuggling of Weapon Technology

Finding out whether a vessel is suspicious or not is not trivial. Of course, if the behavior of the vessel is strange, then operators may notice this by just monitoring an area of the sea. It is also relatively easy to identify vessels whose AIS information is not correct, such as the destination of a vessel. This is not sufficient if a vessel behaves normally.

That a vessel can be suspicious while its behavior and information on crew, cargo, and owner are fine can be best illustrated by a news article that was published in June 2010 in the New York Times [1]. In this article it is illustrated how countries such as Iran are establishing a network of vessel owner companies that maintain a continuously changing fleet of vessels. In every transition of owner, the vessels change their identification. This means that not only the name of the vessel changes, but also unique identifiers that are passed in AIS messages such as the MMSI and IMO number (cf. Sect. 1.5.1). By doing this, vessels can be used to transport sensitive cargo such as nuclear weapons and products for countries that are not supposed to have access to them.

To illustrate the above case of finding background information, we use the example of the Indian vessel company WMA. Note that this scenario itself is fictional, but consists of elements that have happened in practice.

WMA is a medium sized company that has several tankers, container and cargo ships in its fleet. A vessel of WMA is appearing before the coast of Rotterdam. There are no issues with the approach the vessel takes to go the harbor, or with its AIS information. Also, the flag of the vessel company (India) does not raise alarm bells. The vessel enters the harbor, releases its goods, takes on new good and leaves for a next destination.

A few months after this event, Iran is involved in an attack in which a fast attack patrol craft was used. The type of craft can carry torpedoes and is therefore forbidden technology for Iran to possess. Iran was able to obtain this type of fast attack patrol craft through vessels of WMA. A vessel of WMA loaded this type of patrol craft a few months ago in the harbor of Rotterdam. WMA is affiliated to an Iran vessel company. WMA is smuggling for Iran, since also the identity of the vessel that was used in the smuggling is relatively new and can be traced to other companies.

2.4.5 Terrorist Actions

The context of the following scenario is a hypothetical situation in which the Dutch coast is confronted with “Non-Cooperative Maritime Actors”, i.e. terrorists. Operators in the coast guard center notice that a part of the Dutch coast has less sensor coverage than normal. In this area AIS information is less reliable. An investigation is started to determine if the behavior is explainable through natural causes, such as bad weather areas.

To cope with the reduced sensor coverage an airplane is sent to investigate the situation at sea. Also, a coast guard vessel that carries its own AIS base station is sent out. The vessel relays the received AIS data to the coast guard center.

The reduced sensor coverage takes longer than expected. Therefore, a maintenance engineer is sent to the AIS base station that produces less reliable results. Upon arrival at the base station, the engineer notices that someone tampered with the station.

The tampering of the base station makes this incident a terrorist action. Although the coast guard responded adequately in coping with the reduction in sensor coverage, the area was unobserved for some time. Deploying the vessel and airplane simply takes time.

2.5 Challenges for System Support

Finding incidents in large areas is not a trivial task. Smugglers, drugs traffickers, and terrorists are aware of what organizations can and cannot find, and are creative in hiding themselves. MSS organizations, therefore, have to look for details in the movement of vessels and other information that can be associated to vessels. This usually means combining several information sources, and reasoning on the information to reach a decision.

It is clear that if MSS organizations are adequately supported by systems that provide the right information at the right time, they are able to find more incidents and work more efficiently. The challenges of such a system can be summarized as follows:

- Alert operators when needed –

It is commonly known that observing a situation for some time is a tedious task and that it may be difficult for operators to keep full attention. Consequently, an effect is that operators may not continuously monitor a situation. This may result in a late response to, or even completely missing of an event. Because of this, operators need a system that operates in the background and that alerts them when needed. In the meantime the system is responsive so operators can use it to investigate vessels and find their background data.

In Sect. 2.4.1 we discussed a number of violations to traffic rules. These violations can be categorized as geo-spatial violations and information violations. Geo-spatial violations concern speeding and sailing against the traffic. Information violations concern wrong specification of cargo, or a wrong destination. In case of geo-spatial violations, operators would be helped with an alert when a vessel is sailing against the traffic.

- Provide a historic overview on vessel movement to operators –

One of the largest problems for operators is to have a clear view of how vessels move over time. This movement may change over time. For example, in case of bad weather, vessels may be forced to go for anchor at unexpected places, or may deviate from their course. Also, the season may have effect on traffic. Fishing, for example, is not allowed during the whole year. It may also be that temporary situations have impact on traffic. For example a construction site at sea results in a change in the movement pattern in that area. Having an overview of vessel movement in the past in combination with the knowledge that construction activities are deployed in an area, allows operators to compare and decide whether actions are needed.

Operators have special attention for areas where vessels cross each other. The reason for this is that these areas are more likely to have incidents because there is more activity in that area. Typically, these are the areas where sea lanes join or cross each other. When observing vessel movements in an area, however, there appear to be more areas than the most obvious ones. Knowing the areas that, from a historical perspective, have vessel crossings, improves the understanding of a situation.

- Provide interaction to the system, so operators can loop back over time to check vessels –

For operators it is difficult to notice whether vessels have some kind of interaction. A number of interaction patterns can be identified, for example:

- Follow pattern: Vessels follow each other at close distance;
- Rendezvous pattern: Vessels meet each other at open sea;
- Package dropping pattern: Vessels that stop or slow down, speed up again, in combination with vessels that do the same, where the stop or slow down is in the same area.

These patterns are typical for smuggling. They are also difficult to detect since the event evolves over some time and the moment of transfer may be short. In fact, it may be difficult to detect this type of behavior at the moment of occurrence. It would therefore help operators if they can loop back in time and replay the movement of vessels to analyze the behavior they show.

- Support the operator in up-keeping the quality of data when a sensor or other system part fails –

We discussed the combination of information by operators. The information itself is coming from several sources. The sources can be sensor systems, information systems, or information services. Most often these sources come from different vendors or rely on infrastructures that are not controlled by the organizations that use them. The latter applies to most web-based services. The availability of information sources is not guaranteed. This means that the system as well as the operator himself must be aware that a source may not be available. A system should therefore be able to handle unavailability of information sources and integrate an information source when it is added to the system or when it comes online.

This chapter introduced various challenges for improving situation awareness in the domain of maritime safety and security. The next chapters of this book will elaborate these challenges and work on solutions.

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