Increase of Combat Effectiveness of Warships with the Introduction into Operation of WECDIS

Povećanje borbene učinkovitosti ratnih brodova uvođenjem sustava WECDIS

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Summary

This paper analyses the possibility of increasing combat effectiveness of warships with the introduction into operation of Warship Electronic Chart Display and Information System (WECDIS) on board ships. This navigation computer information system, which complies with the rules of the International Maritime Organization (IMO) and NATO STANAG 4564 (Standard Agreement 4564) helps the navigational officer in his daily work. Navigational officer has the ability to use different tools and information necessary for the protection and efficient use of a warship.

The emergence of new technologies in the field of warfare is in the most aspects of naval operations computerised and digitalised with the intent to build, display and allow manipulation with the Recognised Maritime Picture (RMP). It is therefore surprising that a lot of Navies are still navigating using only paper charts although the advantages and efficiency provided by the WECDIS, if used correctly, are significant.

In the first part of the paper WECDIS is analysed as a navigational system used on warships with all the advantages and disadvantages recognised during its use in navigation. In the second part an increase of the combat effectiveness of warships during execution of different warfare operation is analysed.

KEY WORDS
Warships
WECDIS
Combat Effectiveness

Sažetak

U radu se analizira mogućnost povećanja borbene učinkovitosti ratnih brodova uvođenjem u rad elektroničke pomorske karte i informacijskog sustava za ratne brodove (WECDIS). Ovaj navigacijski informacijski računalni sustav, koji je u skladu s pravilima Međunarodne pomorske organizacije (IMO) i NATO STANAG 4564 (Standardni sporazum 4564), pomaže navigacijskom časniku u njegovu svakodnevnom radu. Navigacijski časnik ima mogućnost korištenja raznih alata i informacija potrebnih za zaštitu i učinkovito korištenje ratnog broda.

Nove tehnologije u ratovanju su u većinama operacija ratne mornarice računalizirana i digitalizirana s namjerom da se napravi, prikaže i omogući manipulacija uz pomoć Prepoznate pomorske snimke (RMP). Stoga iznenađuje da veliki broj mornarica još uvijek koristi papirnate karte, iako su prednosti i učinkovitost koje pruža WECDIS, ako se pravilno koristi, velike.

U prvom dijelu rada WECDIS se analizira kao navigacijski sustav kojim se koristi na ratnim brodovima sa svim svojim prednostima i nedostacima tijekom uporabe u plovidbi. U drugom dijelu analizira se povećanje borbene učinkovitosti ratnih brodova tijekom izvođenja različitih ratnih operacija .

KLJUČNE RIJEČI
ratni brodovi
WECDIS
borbena učinkovitost

INTRODUCTION / *Uvod*

The navigational officer on board a warship is responsible during his watch to monitor the operation of all ship systems, supervise the work of the members of the navigational watch and other routines during the voyage. When on watch the navigational officers use different data sources in order to conduct safe navigation and determine the exact position of the ship on the nautical chart and the ship's location in relation to other ships. In addition to keeping safe navigation, the navigational officer on board of warship must contribute to the efficient use of the combat systems by performing an appropriate manoeuvre. Saturation or lack of data provided by various navigation devices has often been the cause of a relatively large number of accidents at sea.

The navigational officer on board a warship needs to have more time to monitor tactical situation, thus various navigational information systems for navy ships like WECDIS[1]

[1] The W-ECDIS (Warship - Electronic Chart Display and Information System) complies with IMO regulations valid for ECDIS as well as with NATO standards (STANAG 4564 – Standard Agreement 4564 - Edition 2). The purpose of this agreement is to define the standards for WECDIS fitted on board of navy ships of the NATO member states, in order to allow a minimum number of common functions and the possibility of exchange of digital information in a standard

are being developed.

The purpose of WECDIS is to display the appropriate2 electronic navigational charts (ENC)3 and combine all maritime safety information (MSI) in order to increase safety of navigation. The system also displays other additional information provided by a variety of ship systems used in support of the weapon systems, with the aim of increasing the effectiveness of naval warfare. The system receives information from the environment, integrates it and displays to the navigational officer through a customised interface, which he uses for the protection and efficient use of the navy ship.

The WECDIS is therefore a computerised navigational information and combat system which helps the navigational officer in the decision-making process. The system also simplifies this process. Time saved in the collection of navigational data and data from the combat systems enables the navigational officer to pay more attention to prevent collision and to manage combat systems during naval operations.

A certain number of navies recognised the benefits of such systems, and introduced them into use on board their ships.4

WECDIS (ECDIS – N) AS A PART OF A SYSTEM / *WECDIS (ECDIS – N) kao dio sustava*

WECDIS can be displayed as a part of a technological system, where elements of the system are connected interactively with each other, in order to achieve the optimal development of the system as a whole from the standpoint of the state and changes of this state in the environment surrounding them.

The structure of technological systems usually differentiates three specific groups of elements:

- Physical (WECDIS, warship, navigational officers and principal warfare officers),
- Creative (communication and information structures linked with the space, navigational and principal warfare officers with a part of their intellectual potential) and
- Symbolic elements (different conventions, STANAGs, organisations and prescribed standards). [4]

The WECDIS subsystem, in constant interaction with the environment, integrates all the data collected by various devices in the environment. The system presenting these data on board for the navigational officer, gives him relevant information required for safe navigation and monitoring over the tactical situation on the sea and the efficient use of the combat systems.

WECDIS subsystem can be viewed as a system, where the computer using input - output link is connected with certain navigation sensors [7] and indicators of various ship systems in support of the combat system. Therefore, WECDIS can be said to integrate besides navigational data in the electronic chart the information relevant to the tactical use of a warship such as Warship Automatic Identification System (WAIS) data, Additional Military Layer (AML)5 data, underwater navigation data and it displays firing sectors and ranges of naval weapon systems, etc.

In practice, WECDIS (ECDIS-N) is also encountered as a part of an integrated navigation bridge6 like those installed on board of certain U.S. Navy ships (the Nimitz-class aircraft carriers, Arleigh Burke class destroyers and Wasp class amphibious ships) [25].

WECDIS IN NAVIGATION / *WECDIS u plovidbi*

Basic navigation functions of WECDIS comply with performance standards of IMO for ECDIS. Combined with GPS and digital navigation maps WECDIS provides superior navigation capabilities by using an interactive computer system. In the traditional methods of navigation there is a time delay between taking navigational position, plotting on the map and comparison with planned route of navigation. In this way a certain position represents the position of the ship at a given time, rather than the current position of the ship which is extremely important for warships. WECDIS using positions obtained via GPS constantly displays the position of the ship in real time on a screen. This can be a huge advantage in dangerous combat situations and areas of high density of traffic. [19]

Nevertheless, NATO sets its additional requirements for the modified functions, both for navigation and combat. To support these required changes, NATO prescribes certain requirements for digital data to be used within WECDIS. WECDIS must be able to display and process the digital navigation data given by authorised government organisations (hydrographic organisations, military data centres, etc.).

Contemporary work on modern warship bridge without WECDIS is turning to be unthinkable. For example, the US Navy fully digitalised navigation systems on their ships in October 2009. [19] Some of the Navies, such as The Royal Navy, learned from their own mistakes about the importance of the existence of such systems in modern and expensive ships and submarines. Grounding submarine HMS Astute (Figure 1) indicated the Royal Navy command to install WECDIS to all submarines of this class.7

format defined by relevant NATO procedures. According to the IMO Resolution MSC.226 (82) ECDIS is a navigation information system which in legal terms and with adequate support can be accepted as equivalent of an updated nautical chart required by regulations V/19 and V/27 SOLAS Convention. The WECDIS is also known as ECDIS-N (where N stands for the Navy).

[2] IHO standards relating to electronic navigational charts are contained in the publications S-57 and S 52. S-57 defines the type, amount of data and the characteristics for each object in the real environment. S-52 includes a set of rules on how to interpret and display objects from the real world on the screen. See also [6].

[3] Electronic navigational chart is a digital database prepared in accordance with the product specifications of the IHO S-57. It contains all relevant information necessary for safe navigation, such as coastline, bathymetry, buoys, lights, etc. Geographic coverage analogous to a paper chart is the basic unit for the ENC and is called cell. IHO S-57 specifies which information from nautical chart will be coded. The ENC display mode in ECDIS and other key rules for the use of ENC have been determined in the IHO Standard S 52. A National Hydrographic Office (NHO) responsible for the preparation of official ENC must adhere to these standards. A NHO who wants to protect its own ENC from unauthorised use and misuse can apply the IHO standard S-63. See also [3].

[4] The Royal Navy was the first navy in the world that installed WECDIS compatible with NATO standards on board of its ships. The first contract for equipping ships was signed in January 2004. The equipping began in July of the same year, first on destroyers and frigates, and then the other smaller ships. Other navies followed the example (The U.S. Coast Guard in August 2007, The Royal Australian Navy in October 2007, Brazilian Navy in February 2008 and the Royal Netherlands Navy in August 2009. See also [27].

[5] Additional Military Layers comply with the NATO standardization agreements. AML represents digital geospatial data, with the purpose to improve operational efficiency in the maritime and littoral environment through superior situational awareness. AML is an initiative of NATO, coordinated by the United Kingdom Hydrographic Office (UKHO) to enable comprehensive, integrated digital information for users of defence systems. Type of information that provides AML service includes display of bathymetric contours, routes, territorial water areas and fishing zones, hazardous zone areas and Q - routes, wrecks and large objects on the seabed, sea mines, detailed information on the type of seabed, climatological data including salinity, temperature, etc. See also [10] and [24].

[6] See also [2] and [20].

[7] HMS Astute submarine grounded south of the Crowlin Islands on 22nd November 2010. The submarine is one of the most modern nuclear submarines in the world. Reasons for grounding were failure to comply with the procedures for planning and performance of navigation and lack of vigilance by the navigating officer at the proximity of danger. After an investigation, the Royal Navy committee determined among other things that all submarines of this class have to be

Figure 1 Submarine HMS Astute aground south of Crowlin Islands [22]
Slika 1. Podmornica HMS Astute nasukana južno od otočja Crowlin [22]

WECDIS provides navigational officers various navigation data in the form of information, the ship's position and situational awareness. The system displays the position in the World Geodetic System 1984 (WGS-84) format and has the ability to convert other systems in the WGS-84 with automatic correction. Latitude and longitude are displayed in degrees, minutes and parts of the minutes to the required level of accuracy (e.g., 44° 17.456'N). Data within the database have an automatic (semi-automatic) and manual restoration.

WECDIS as an automated and computer-assisted system helps the navigational officer in the decision-making process, with an additional alarm system that allows alert in case of groundings and collisions at sea. Depending on the type of system WECDIS provides different parameters required for safe navigation, such as the display position of the ship, the choice of optimal navigation routes, route tracking, the radar images display, navigation in shallow waters, etc. [7].

In addition to these parameters the situational awareness provided by these systems is a particularly important parameter for warships. Using civilian versions of an Automatic Identification System (AIS) or military version of AIS (Warship Automatic Identification System - WAIS)8 that is integrated within WECDIS provides the navigational officer with better situational awareness unlike the automatic radar plotting aid or conventional radar. [21]

In addition to the standard requirements for ECDIS to be met, WECDIS must meet additional standards whose number will largely depend on the type, size and purpose of the warship. This primarily refers to the ability to use WECDIS in underwater navigation (submarines), the use of AML, sea surface control, route control, alarm systems and capabilities to make recording of navigation. The ability to record navigational data such as courses, turning points, rudder position, navigator's notes (turning on - off the navigational lights, rotary wing operations on the deck, plans, areas and navigational routes), with no possibility to change the data recorded, is used for the purposes of investigation of possible accidents at sea.

Data received via NAVTEX (Navigational Text) 9 system are displayed on WECDIS screen with the aim to further enhance SA. ECDIS enables printing of these messages and there is no longer the need to use specific printers for NAVTEX. In addition to the display of MSI ECDIS enables also display of weather map combined with nautical charts. This allows optimisation of the planned sailing route in relation to fuel consumption, safety of navigation and the estimated time of arrival at the destination. Time parameters that can be displayed on the system include the direction and speed of wind, wave height, currents, atmospheric pressure, the weather situation and the air temperature. Among other special navigation functions it is important to mention the existence of the possibility of monitoring the movement of ship's boat on the system screen. Moreover, during maritime interdiction operations, or search and rescue operations, warships receive coded signal sent from their own boats on the system screen.

Under these conditions the use of WECDIS will certainly raise the level of safety of navigation, and thus help to reduce maritime accidents and environmental disasters at sea. On the other hand, the system will provide higher quality of RMP and thus enable better monitoring of tactical situation at sea.

Despite of all the advantages certain errors in the use of ECDIS have recently been observed. Users of WECDIS must take these errors into consideration in order to avoid unintended consequences in navigation. The analysis found that the most common errors that have been observed in the use of ECDIS are:

- Human errors,10
- Incomplete definition of standards of the International Electro-technical Commission (IEC) and/or the IHO, which are defining certain alarms, and
- Operating characteristic errors which were not found during verification of the systems.

In accordance with the IHO and IMO recommendations the officers in charge of navigational watch must be familiar with all these errors that have been noticed in daily work with ECDIS and inform the authorities if any other irregularity or error in dealing with the system [7] is noticed.

INCREASE OF COMBAT EFFECTIVENESS OF WARSHIPS WITH THE INTRODUCTION OF THE WECDIS / *Povećanje borbene učinkovitosti ratnih brodova uvođenjem sustava WECDIS*

The Navies in general are responsible for naval defence of their countries and they are part of overall military power of their own states. The purpose of the Navies is the defence of national sovereignty, the protection of national interests, and the projection of military power in their area of responsibility. [16]

Naval forces develop capacity to participate in the supervision and protection of marine and underwater areas of the coastal state. In addition, naval forces often support civilian institutions through participation in the prevention and elimination of consequences of natural or manmade disasters, transport of vulnerable persons from islands to mainland and in search and rescue operations [23].

equipped with WECDIS in order to reduce the possibility of such events in the future. It was concluded that the existence of such a system would significantly help to avoid grounding because the system would allow the navigating officer to have a better overview of the situation at sea. See also [22].

[8] WAIS allows the user to operate in normal or hidden mode, and provides an opportunity for the exchange of information about the monitored contacts via text messages. This allows the creation of clear situational picture (Situational Awareness - SA). See also [25].

[9] The NAVTEX is used to receive MSI. See also [8].

[10] Several human errors have occurred over the years of use of ECDIS on merchant ships. These errors have caused a series of maritime accidents. The well known cases are accidents of the m/v Pride of Canterbury and the CFL Performers. These errors should be considered in order to avoid similar situations in the future. See also [21].

The following section elaborates some of the combat capabilities of warships and gives an overview of the tasks of the Coast Guard ships, which ability would be improved by introducing ECDIS (WECDIS-a) into operation.

Surface warfare capabilities / *Mogućnosti ratnih operacija na površini*

Combat missions of surface warfare ships include the execution of anti-surface warfare (artillery and missile strikes), anti-submarine warfare and electronic warfare activities [9].

A study of The Norwegian Royal Navy carried out on board of fast patrol boats showed some advantages provided by using ECDIS in navigation compared with the conventional methods of navigation using paper charts. It was found that during conduct of maritime operations with the use of ECDIS there was a significant improvement in terms of keeping the planned course and safety of navigation and the communication between crew members on the bridge was considerably shortened and simplified. [5]

Regard to the purpose and nature of the tasks each second is crucial in the conduct of combat operations for surface warfare ships and therefore some automation in the process of determining the position of own and adversary ship is absolutely necessary.

Without the existence of WECDIS, the non-commissioned officers on the bridge and in the combat operational centres in these types of ships are constantly plotting ship's position trying to monitor and update the entire SA. In combat situations where the tempo of work is high, this can lead to errors because several persons are trying to determine the position in two different places at the same time. Progress achieved by using WECDIS for naval vessels in the tactical and navigational terms, showing a constant position of the ship on two screens on the bridge and in combat operations centre, is significant [19]. Consequently, the missile strikes using this system in support will be improved, primarily due to the possibility to obtain a clearer and more complete RMP. Also, missile strike could be planned in advance and displayed on the screen of WECDIS anywhere in the area covered by the electronic chart. The fact that the system has the option to record the ship tracks as well as tactical manoeuvres and orders issued, would allow reconstruction of the mission or even the whole operation.

Possible use of this type of ships in Maritime Interdiction Operations (MIO) further justifies the installation of WECDIS (ECDIS) which will provide an additional source of RMP. A clear RMP at night and at high density of maritime traffic is extremely important during the MIO. The ability to display data from an integrated WAIS on screen of WECDIS and possibility to exchange data with other friendly ships certainly increases the efficiency of warships involved in the MIO.

Anti-submarine warfare would be easier if the ships were equipped with WECDIS. The system, among other things, enables the view of isotherms on the screen (Figure 2), which are used for analysis of diffraction of acoustic signals with the aim to detect submarines. In addition to this feature, the system allows for selection of the probability of detection of submarines in the monitored sea belt.

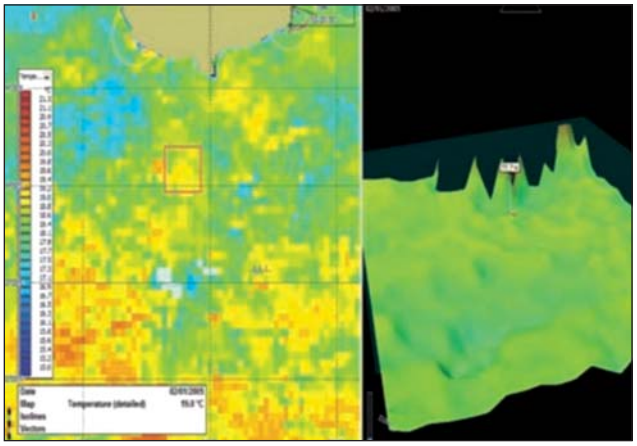

Figure 2 Isotherms in the marine environment [26]
Slika 2. Izotermi u morskom okolišu [26]

Search and rescue (SAR) operations as one of the possible tasks of these ships would be greatly eased by using WECDIS which would allow the navigating officer effective planning, implementation and monitoring of the operation.

Capabilities of mine warfare ships / *Sposobnosti protuminskih ratnih brodova*

During mine-warfare operations, efficient mine laying is achieved by conducting accurate navigation. The basic methods of determining the positions of minelayers in navigation are measuring azimuths with radar or using GPS device. In cases where the coast and islands are well rugged, the mine-laying task is simple, unlike the case when minelayer lays mines on the high seas outside of inland waters, where alternative technical options for conducting navigation must be used.

Due to required high level of accuracy of positions of mines laid, it can be said that the same cannot be achieved by determining the ships position taking the azimuths at greater distances from the navigation orientation objects. Errors in azimuth for the total repair result from incorrect value of deviation and variation of the magnetic compass or gyro compass deviation. In addition to these errors, we have to mention the random errors, errors in readings, and mapping error. In favourable conditions, this is an error moving in the gyro compass up to 0.5° and the magnetic compass to 1°. Although the azimuth is defined as the line of positions, it is, in fact, the sector of positions [1].

For this reason, and in order to increase the navigation accuracy, this type of ships introduces the use of electronic maps showing the GPS position of the ship and alternative methods of determining position are also used. Additional navigation systems, modernisation of mine-laying ships, which would be achieved by introducing WECDIS, would allow the achievement of a higher degree of combat readiness of this type of ship. Also, the system would enable the exchange of data on the navigation plan and the mine barriers in NMEA format, between mine laying ships and friendly forces (national and coalition), which have WECDIS [26].

WECDIS would, whenever used on mine laying ships, significantly contribute to the increase of their combat and

navigation capabilities.

Tasks of mine counter measures ships are mine action against the standard and improvised mines. Use of electronic charts on mine hunters, as means of support in planning and execution of mine warfare tasks, would certainly simplify complicated tasks of such major carriers of MCM operations.

Purpose of mine hunters is detection and destruction of sea mines. Mine hunters using sonar detect and classify mine-like contacts and if necessary send divers or remotely operated underwater vehicles to explore and destroy sea mines [12]. These ships during MCM operations pass through the areas of mine fields, where any superficiality or technological unpreparedness can lead to errors and damage the ship. Incorporating WECDIS, on this type of ships, these tasks would be more efficient and safer to plan and oversee and support the mine divers and the execution of their tasks would be enhanced. Figure 3 shows the possibility of tactical use of WECDIS in hunting mines. The system enables you to view the seabed, through the elements of bathymetry, sediment and 3D view of the area in which the mine hunting is conducted [26].

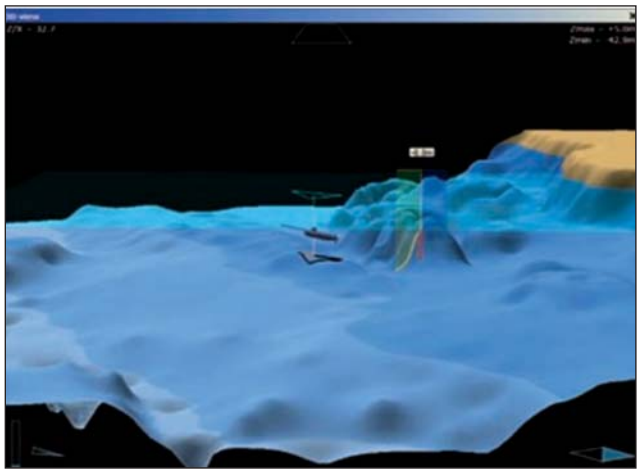

Figure 3 The 3D overview of sea bed and mine hunting area on WECDIS [26]
Slika 3. Trodimenzionalna slika morskog dna i minskog područja na WECDIS

In addition to these features the system provides the user an overview of all AMLs that are in the database, such as MCM contacts and Q-planned routes. In this way, you can better control the tactical situation on the sea and the seabed. These technical specifications would certainly contribute to the development of additional MCM capabilities of the navies. Apart from the tactical point of view it must be emphasised here the possibility of keeping safe navigation through the route planning, meteorological protection of navigation, ship management operations, search and rescue, marking mine fields laid obstacles (data exchange with mine laying), etc.

Capabilities of Coast Guard ships / *Sposobnosti brodova Obalne straže*

The Coast Guard is a military or civilian agency with police powers at sea. It is intended to protect the sovereign rights and the implementation of the jurisdictional powers of the parts of the sea in which coastal states exercise such rights and powers [15].

Installation of ECDIS (WECDIS) on the Coast Guard ship, except the possibility of keeping a safer navigation, would enable better planning of search and rescue operations, implementation of monitoring, control and protection of fishing activities.11 Specifically, protection of fishing activities and marine environment is directly enabled by connecting with systems such as ARGOS.12 Also it would be possible to monitor the area in order to prevent the smuggling of drugs and other illegal activities, and monitoring of certain protected zones [27], marine environment protection, etc.

Of course, these ships by installing WECDIS would increase their combat characteristics in a similar way as warships. In general, it depends on the type of ship and its equipment in combat systems that would be used in cases where it would be engaged in combat operations.

CONCLUSION / *Zaključak*

Accidents at sea most of which ended up with stranding ships, are caused by human error. Introducing WECDIS on warships, in terms of navigation, they would get a valuable navigational aid which would certainly contribute to the avoidance of accidents at sea. In doing so, the officer on watch must be aware of the limitations of this system and the danger in case of failure, such as loss of signal from the GPS device, etc. It is therefore very important to ensure proper training of navigational officers in working with the system, to get familiar with all its advantages and disadvantages.

WECDIS should not become the only means for conducting navigation and at the same time create a false sense of security to the officers on watch. Along with other forms of electronic navigation, WECDIS represents only a navigational aid.

Technical features and benefits provided by WECDIS allow officers on watch accurate, simpler, safer and more efficient implementation of operations and combat missions. Also obvious benefits that would be derived using WECDIS are in anti-submarine warfare, mine warfare, anti-surface warfare, MIO, SAR, enforcement of suspected ships through dangerous areas, fisheries surveillance and protection of the marine environment.

The introduction of this system on warships would simplify the decision making process and significantly shorten the time of the decision, while simultaneously improving the combat capability. Owning RMP as one of the critical factors in the implementation of operations and combat missions could be realised through WECDIS.

[11] As an example we can take the Indonesian Coast Guard which has installed this system on their ships in order to control fishing boats, where the system is coupled with the ARGOS system. See also [26].

[12] ARGOS system is unique worldwide location and data collection system, designed for the study and protection of the environment by satellite. The purpose of the system is to connect entities such as moving platforms, fishing boats, buoys and a variety of wildlife in a single system, in order to protect the marine environment. The system allows you to send data on the subjects to all parties concerned. Connectivity is possible with all those who have ARGOS transmitter. In this way it is possible to conduct surveillance of fisheries, collecting data from the marine environment such as temperature, salinity, currents, monitoring of hazardous materials and racing sailors. Many governments use ARGOS in order to monitor the marine ecosystem and to ensure responsible fisheries. See also [18].

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