ATLANTIC CENTRE
For Defence Capacity Building
POLICY BRIEF ISSUE 06 | FEBRUARY | 2021

Maritime Situational Awareness – the Portuguese Navy dual-use approach

Filipe Gonçalves Dias[1], João Fidalgo Neves[2] and Victor Plácido da Conceição[3]

INTRODUCTION

About 80% of today's world trade volume is done by sea, including raw materials, finished goods, food, fuels, and others.[4] The United Nations Conference on Trade and Development (UNCTAD) forecast an average annual growth by 2022 of 3,2%.[5] So, it is clear that the world merchant navigation is growing, contributing to increased safety and security challenges at sea. The Portuguese Navy (PN) faces additional challenges, like the possible extension of more than 120% of the Portuguese continental shelf area, or the increasing number of merchant ships with Portuguese flag,[6] bringing new responsibilities as suggested by the Montego Bay Convention.[7] This conjecture requires improvements on the capability to access new types of data, information production about Maritime Situational Awareness (MSA) and dissemination. These requirements are needed to increase the level of awareness and quickly define areas of interest by the competent entities, contributing to enhanced maritime safety and security.

1 Navy Lt, CINAV, Portuguese Navy Research Centre
2 Navy Cdr Eng, CINAV, Portuguese Navy Research Centre
3 Navy Cdr, CINAV, Portuguese Navy Research Centre
4 UNCTAD, «Review of Maritime Transport», United Nations, Geneva, 2017
5 UNCTAD, «Review of Maritime Transport», United Nations, Geneva, 2017
6 UNCTAD, «Review of Maritime Transport», United Nations, Geneva, 2017
7 REPÚBLICA PORTUGUESA Assembleia da República, Resolução da Assembleia da República no 60-B/97, Diário da República, I Série no 238, 15 de outubro de 1997, pp 5486-(3) - 5486-(192)

The views expressed reflect the opinion of the authors
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The Portuguese Maritime Operation Centre (COMAR) and Maritime Rescue Coordination Centre (MRCC Lisbon) are two Command and Control (C2) centres, standing in the same space and organisational structure, under the responsibility of the Fleet commander of the Portuguese Navy. Their primary objectives are, respectively, "To guarantee the exercise of State authority and security in maritime spaces"[8] and "Save the lives of those who practice the Portuguese sea"[9]. Since the Portuguese Navy Shipping Centre (PNSC) creation in November 2017, these two centres are also tasked to monitor, advise, and protect all the Portuguese flagships worldwide. Therefore, beyond supporting naval operations and coast guard duties, they are also responsible for all vessels' safety and security using Portuguese jurisdiction waters, both for the traditional activities and emerging economic activities like aquaculture or offshore renewable energy. At COMAR / MRCC Lisbon, to ensure the highest safety and security level, monitoring and decision-making are supported by information systems that provide the Recognised Maritime Picture (RMP) and offer redundancy in acquiring Maritime Situational Awareness (MSA).

Based on a previous publication[10], this paper attempts to identify the theoretical framework for defining operational requirements necessary for the improvement of MSA functions, supporting the PNSC missions by studying the MSA concept and the Situational Awareness (SA) model adopted in the Portuguese Navy (PN).

Considerations are made over the definition of Situational Awareness (SA) adopted on three consolidated models, which are then compared with the PN approach on MSA. After some analysis of their strengths, differences and limitations, and the PN's actual methodology, a model is presented to be adopted for the definition of requirements.

8 PORTUGUESE NAVY SHIPPING CENTRE, GUIDANCE AND GUIDELINES - Standard procedures for merchant vessels hoisting the Portuguese national flag. Lisboa: PORTUGUESE NAVY, 2017.
9 PORTUGUESE NAVY SHIPPING CENTRE, GUIDANCE AND GUIDELINES - Standard procedures for merchant vessels hoisting the Portuguese national flag. Lisboa: PORTUGUESE NAVY, 2017.
10 Dias, F. G., Neves, J. F., Conceição, V. P. da, & Lobo, V. J. A. S. (2018). Maritime Situational Awareness, the singular approach of a dual-use Navy. Scientific Bulletin of Naval Academy, XXI(1), 203–215. https://doi.org/10.21279/1454-864X-18-I1-033.

MSA CONCEPT

According to Gilson, the concept of SA was identified during the first World War by Oswald Boelke, who realised the importance of being aware of the enemy before he has the same level of consciousness as his opponent, and defined methods to achieve this end[11]. The idea of the existence of two distinct realities, the operators' perception over a system and the actual state of a system, is the basis of the definition of the concept of SA[12]. This idea did not receive much attention until the 80s, but it has been a central theme in scientific research since then. The main responsibility for the origin of the concept and increasing studies in this area was undoubtedly the aviation industry. There was enormous stress on pilots and air traffic controllers to be as aware as possible of the air environment to have the highest possible level of what it would be called SA, guaranteeing good levels of safety and security.[13]

The importance of having a good SA level was initially related to the idea of maintaining a secure control over an aircraft could not be underestimated, knowing the increasingly dynamic, complex and consequently dangerous air environment where it operates. A study of more than 200 aircraft accidents suggests that the lack of SA is the leading cause of it.[14] In fact, in her studies[15], Endsley shows how most of the accidents are associated with compilation issues and visualisation or lack of information on the system's primary problems in designing the system. There are several definitions for SA which can be broadly summarised in three, as follows:

- The perceptual cycle of Smith & Hancock defines SA as "the invariant in the agent-environment system that generates the momentary knowledge and behavior required to attain the goals specified by an arbiter of performance in the environment"[16]. Originating from

11 R. D. GILSON, «Situation Awareness - Special Issue Preface», Hum. Factors J. Hum. Factors Ergon. Soc., vol. 37, n. 1, pp. 3–4, 1995.
12 D. D. WOODS, «Coping with complexity: The psychology of human behaviour in complex systems», Tasks, errors, Ment. Model., n. JANUARY 1988, pp. 128–148, 1988.
13 R. S. JENSEN, «The Boundaries of Aviation Psychology, Human Factors, Aeronautical Decision Making, Situation Awareness, and Crew Resource Management», Int. J. Aviat. Psychol., vol. 7, n. 4, pp. 331–341, 1997.
14 C. E. J. HARTEL, K. SMITH, e C. PRINCE, «Defining Aircrew Coordination», at the Sixth International Symposium on Aviation Psychology, 1991.
15 M. R. ENDSLEY e D. G. JONES, Designing for Situation Awareness, 2.a ed. New York: CRC Press, 2004.
16 K. SMITH e P. A. HANCOCK, «Situation Awareness Is Adaptive, Externally Directed Consciousness», Hum. Factors J. Hum. Factors Ergon. Soc., vol. 37, n. 1, pp. 137–148, 1995.

Niesser's work on the perceptual cycle model, it describes an individual's interaction with the world and the role of this world's conception or schemes in this interaction.[17]

- The Bedny & Meister definition is based on the Activity Theory (AT), stating that: "Situational awareness is the conscious dynamic reflection on the situation by an individual. It provides a dynamic orientation to the situation, the opportunity to reflect not only the past, present and future, but the potential features of the situation. The dynamic reflection contains logical-conceptual, imaginative, conscious and unconscious components that enable individuals to develop mental models of external events".[18] AT is an interactive, cognitive, and subsystem approach that has been restricted for decades to Russia, the origin country of this model creator (Leont). This approach does not specify traditional cognitive processes, such as perception or memory, or even thought and action.

- Endsley's 3 level SA Model defines SA as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future".

According to Stanton,[19] the three-level model seems to be the most developed, and that's why it will be further developed.

3 LEVEL SA MODEL OF ENDSLEY

Endsley formally defined SA in 1988. To her, the conception of "knowledge" is strongly linked to what kind of information is relevant to a given task or goal. This concept of SA is usually adopted for operational situations mainly because it was designed during software development studies to support the decision of military aircraft pilots and air control and later on to the management of power plants. Following numerous fields studies, such as education,

17 U. NIESSER, «Cognition and Reality: Principles and Implications of Cognitive Psychology», 1976.
18 G. BEDNY e D. MEISTER, «Theory of Activity and Situation Awareness», Int. J. Cogn. Ergon., vol. 3, n. 1, pp. 63–72, 1999.
19 N. A. STANTON, P. R. G. CHAMBERS, e J. PIGGOTT, «Situational awareness and safety», Saf. Sci., vol. 39, n. 3, pp. 189–204, 2001.

pilotage, maintenance, health, weather forecasting, traffic control, etc., Endsley recognises that while the individual elements of SA can vary significantly from one domain to another, its importance as groundwork and foundation for decision making and performance is verified practically in all the domains of application.[20]

This concept of SA disassembles into three separate levels, as illustrated in figure 1. The next level depends on the previous one, the first level being related to the perception of elements in a given environment. The second is related to the understanding of the current situation, and the third and last one associated with the projection or prediction of the future panorama.

The first step to achieving SA is collecting and compiling attributes or characteristics and the state's relevant elements. For each domain, this information's requirements are quite different, and the perception of this information can be made through any sense or a set of senses. Other domains may have different relevant senses.

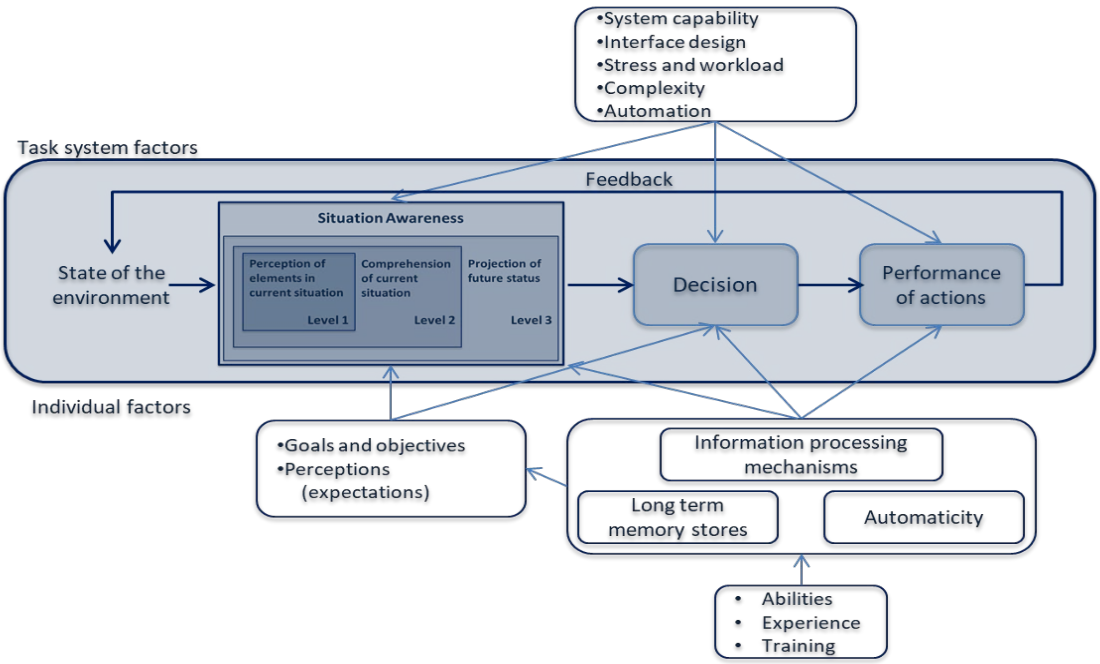

Figure 1 - The model of SA in dynamic decision making of Endsley (2004).

20 M. R. ENDSLEY e D. G. JONES, Designing for Situation Awareness, 2.a ed. New York: CRC Press, 2004.

In the second level of SA, the paradigm is to understand the elements of level 1, assigning them their meaning according to the operator's objective or tasks. It also had to integrate data to generate information and assign levels of importance to this information, possibly prioritising them.

The sharing of this information created from data interpretation is also a very relevant issue, both with other operators and other organisations. It is a key element of this SA level. After knowing the panorama and assigning meaning to the elements that compose this panorama, according to an objective, it can predict these elements' behaviour that characterises level 3 of SA. Therefore, good Level 3 of SA levels are only achieved if there is a good Level 2 of SA and a thorough knowledge of the dynamics of the environment or the domain they are operating. This makes it necessary to create a consolidated mental model, as will be explained next, which is a cognitively demanding task. Having a good level 3 of SA allows being proactive instead of reactive, avoiding undesirable situations.

This 3-level model is built around decision making (see figure 1), with the interaction of the many factors and elements previously expounded. This model, according to Wickens, seems to be very generic, with a significant level of abstraction and based on general cognitive processes, thus offering a theoretical framework with a high number of applications.[21]

Synthetically, SA is mainly influenced by individuals' cognitive limitation when interacting with complex and dynamic systems. Individuals can use numerous mechanisms to overcome these limitations, like having high priority objectives rational focus on objectives, mental models, expectations and automatisms accompanied by sensitivity to the problems they can bring. Moreover, training and experience are fundamental to develop these competencies in a specific domain. Therefore, it is also concluded that SA Level is personal. It varies from individual to individual, although the design of the tool or system witch the individual interacts with the environment also influences a lot the SA level.

21 C. D. WICKENS, «Situation Awareness: Review of Mica Endsley's 1995 Articles on Situation Awareness Theory and Measurement», Hum. Factors, vol. 50, n. 3, pp. 397–403, 2008.

In this context, Wickens states that the discussion between SA and long-term memory remains open. In part because of the concept of SA can be applied to conceptual constructions, such as climate, that can suffer significant changes over a relatively long-time-interval (hours and days). It adds that there is still a group of critics of the Endsley model that raises doubts about this model's validity and viability that defines existing concepts such as attention. The absence of the temporal dimension, or at least a central role of it, is a limitation in the Endsley model that other models have been trying to address but is also a limitation common to other models.[22]

Other researchers in the field of human activity claim that Endsley's approach is logically inconsistent because the concept of SA is represented by just a step in the sequential diagram of the human-information processing system. Bedny & Meister explain that SA, decision making and action, described as phases of information processing, suggests the involvement of the various psychic processes, without which any of these phases can happen, and that is not contemplated in the model. Depending on individuals' specific task, the contents of the psychic processes involved in each "box" vary. Thus, the "Information Processing Mechanisms" box should not be described as an independent stage of information processing. And they add that the variables defined in the model as system capability, interface design and complexity describe the state of the system and can't be interpreted as psychological mechanisms.[23]

PORTUGUESE NAVY MODEL

Formally, the Portuguese Navy does not adopt any of the previously described models but produced a document resulting from the 2011 Naval Directive, which focuses on the Maritime Situational Awareness (MSA). This document[24] addresses this concept from an institutional perspective, establishing standards, norms, and approaches to this concept. Its purpose is to

22 C. D. WICKENS, «Situation Awareness: Review of Mica Endsley's 1995 Articles on Situation Awareness Theory and Measurement», Hum. Factors, vol. 50, n. 3, pp. 397–403, 2008.
23 G. BEDNY e D. MEISTER, «Theory of Activity and Situation Awareness», Int. J. Cogn. Ergon., vol. 3, n. 1, pp. 63–72, 1999.
24 ESTADO-MAIOR DA ARMADA, Conceito de Conhecimento Situacional Marítimo (IOA 114). Lisboa: Ministério da Defesa Nacional, Marinha, Estado-Maior da Armada, 2012.

"establish the MSA concept in the Portuguese Navy (PN), define the lines of action to be followed to build this capability and be the starting point for the assessment of Operational Requirements"[25].

According to the mentioned document, the Portuguese Navy (PN) defines MSA as "the product resulting from the integrated management of a diverse set of data acquisition and processing systems, aimed at understanding activities of interest related to maritime safety and security, facilitating the decision-making process and allowing an effective operational response".[26] This document defines three Knowledge Dimensions (KD), physical, virtual and human, that meet the multidimensional reality characterising the maritime domain. Therefore, the physical KD is defined as "the surface of the sea, the water column and the seabed, the adjacent land and the surrounding airspace and space." The virtual KD is defined as the dimension of knowledge that is associated "to data generated from sensors, information systems and information distribution networks". In this knowledge dimension, the SA is constructed through the cycle compilation, validation, fusion, analysis, and dissemination. Finally, the human KD "comprises social, moral and cognitive elements essential to human action in this context.". This knowledge dimension is responsible for making the MSA production process better, giving feedback, analysing, identifying, and mitigating the error through your organisational culture and experience.[27]

25 ESTADO-MAIOR DA ARMADA, Conceito de Conhecimento Situacional Marítimo (IOA 114). Lisboa: Ministério da Defesa Nacional, Marinha, Estado-Maior da Armada, 2012, p. 1.
26 ESTADO-MAIOR DA ARMADA, Conceito de Conhecimento Situacional Marítimo (IOA 114). Lisboa: Ministério da Defesa Nacional, Marinha, Estado-Maior da Armada, 2012, p. B-1. The original in Portuguese" o Conhecimento Situacional Marítimo (CSM) é o produto resultante da gestão integrada de um conjunto diversificado de sistemas de aquisição e processamento de dados, que visa a compreensão de atividades de interesse relacionadas com a segurança marítima, facilitando o processo de tomada decisão e permitindo uma resposta operacional efetiva" (IOA 114, p.B-1)
27 ESTADO-MAIOR DA ARMADA, Conceito de Conhecimento Situacional Marítimo (IOA 114). Lisboa: Ministério da Defesa Nacional, Marinha, Estado-Maior da Armada, 2012, p. 2-3.

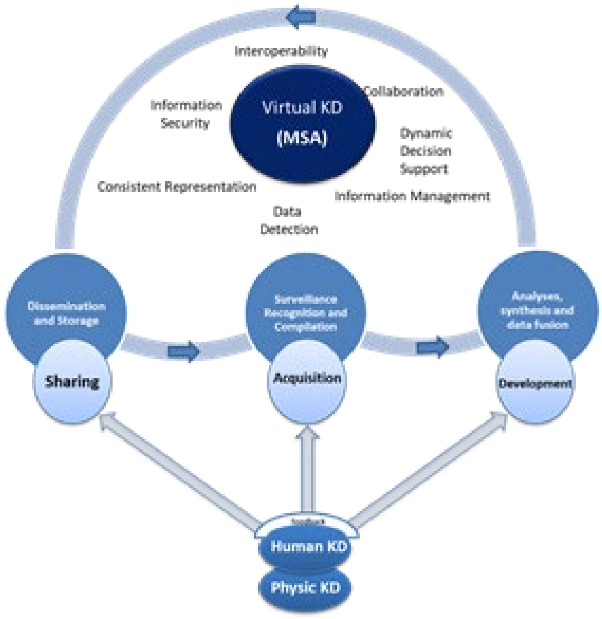

Figure 2 - Author's Interpretation on the Portuguese Navy model of MSA production, based on OODA Loop.

The document explains an approach to MSA production according to the Observe-Orient-Decide-Act (OODA) loop model, interpreted as shown in figure 2.

Boyd's OODA[28] was initially developed in an attempt to explain why American pilots were more successful than their opponents in the Korean war, in the one to one air hostilities "or dog-fight". Hereupon, this model described the activity of pilots in four stages or phases. Later, Boyd developed a more abstract model, as explained in figure 3, for any form of combat.[29] This OODA loop, first presented around 1986, is clearly the current dominant model adopted on Command and Control (C2) matters in the military domain. It is difficult to find a recent briefing in this domain without a reference to this model. This model integrates the military doctrine of several Armed Forces[30] also due to the influence of NATO standardisation. The Portuguese Navy is an example of this, adopting this model to conduct operations from the

28 J. BOYD, «The Essence of Winning and Losing, by John R. Boyd», n. August 1995.
29 B. BREHMER, «The Dynamic OODA Loop: Amalgamating Boyd's OODA Loop and the Cybernetic Approach to Command and Control», Proc. 10th Int. Command Control Res. Technol. Symp. Futur. C2, n. December 2005
30 B. BREHMER, «The Dynamic OODA Loop: Amalgamating Boyd's OODA Loop and the Cybernetic Approach to Command and Control», Proc. 10th Int. Command Control Res. Technol. Symp. Futur. C2, n. December 2005

C2 centres of its naval units. However, besides his briefings, Boyd has published very little in civil society. Thus, this model reaches the present-day mainly by the armed forces, where it is a model widely known and used for its simplicity and objectivity.

It was accessed by interviews for this study that COMAR's C2 centre was conceptualised with the same idea of a warship C2 centre. Therefore, the model adopted to direct action in COMAR is also the OODA loop.[31]

Following this idea, it is explained in the document (IOA 114) that the "Observe" stage presupposes the tasks of Surveillance and Reconnaissance and the compilation of the resulting information, using a sensor infrastructure and all available data sources. At the "Orienting" and "Deciding" stages, are associate the analysis tasks and data fusion. And finally, the task of sharing, that is, the swift, accurate and valid exchange, corresponds to the "Acting" step of the OODA cycle. This document further explains that Archive is part of MSA construction and is defined as the procedure for storing data and information obtained for later consultation.[32] After analysing this approach, it was produced as a model in figure 2.

This model describes a cycle for the production of MSA. It has three distinct phases, Acquisition, Development and Sharing. These phases should be developed with seven fundamental principles in mind (Data Detection and Acquisition, Interoperability, Management of Received Information, Information Security, Consistent Representation, Distributed Collaboration, and Dynamic Decision Support). These principles are criteria that must be taken into consideration to build the capacity of MSA in the systems, networks, algorithms and alarmistic design. Therefore, the operator must know that they have been considered, but it does not affect their actions. In the acquisition phase, it is assumed that the systems carry out surveillance, reconnaissance and compilation activities through the available

31 ESTADO-MAIOR DA ARMADA, Conceito de Conhecimento Situacional Marítimo (IOA 114). Lisboa: Ministério da Defesa Nacional, Marinha, Estado-Maior da Armada, 2012, p. 3.
32 ESTADO-MAIOR DA ARMADA, Conceito de Conhecimento Situacional Marítimo (IOA 114). Lisboa: Ministério da Defesa Nacional, Marinha, Estado-Maior da Armada, 2012.
28 J. BOYD, «The Essence of Winning and Losing, by John R. Boyd», n. August 1995.

sensors. The products obtained in this phase are used in the next stage. In the development phase, it is expected that the systems will carry out analysis, data fusion and alarm production based on predefined or operator-defined criteria. In the sharing phase, it was intended that there be dissemination inside the organisation, externally, and data storage or information, for later consultation. In this cycle, each phase happens permanently, but consequently, from the previous phase, even the way it compiles and recognises information must reflect information previously stored. This cycle produces what the Navy calls MSA, which represents part of the Virtual Domain of Knowledge.

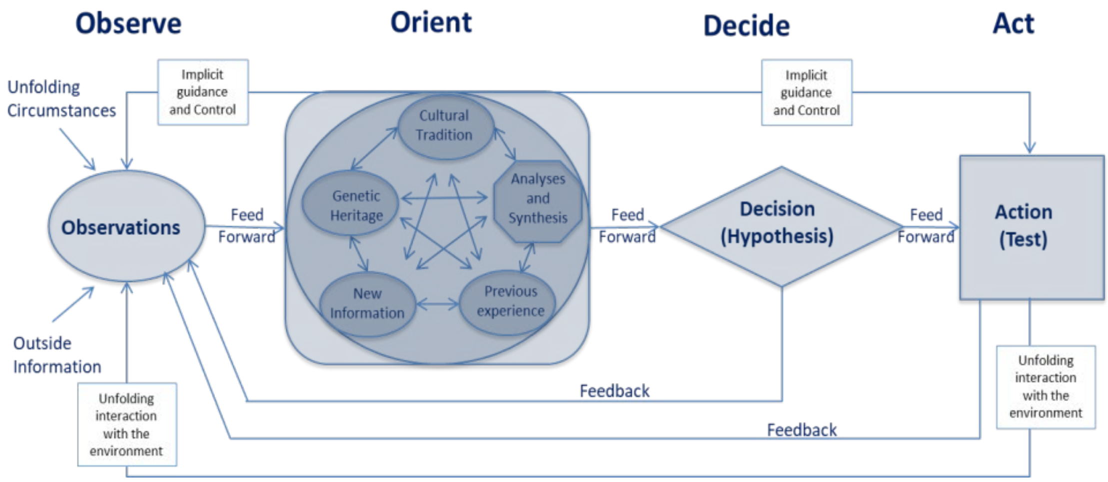

Figure 2 - The Boyd's OODA Loop [28]

When interacting with the MSA production cycle, the human factor (Human Knowledge Dimension) influences how each of these phases is processed. For example, in the Acquisition phase, prioritising surveillance zones, choosing the colour of visualisation, categorising an element that the system did not do for lack of information. In the development phase, introducing alarmistic criteria or prediction criteria, and in the last phase, choosing the most relevant data to share and decide with whom. It is assumed that the human element, when observing and interpreting MSA's final product, creates its conception of the maritime environment, which it uses to interact with it through the OODA cycle. It is implicit that this domain of human knowledge is considered to exist, both at the operator and the organisation level.

As a result of an outcome of systems, this MSA produced is a predominant element belonging to the Observation phase of the ODAA cycle - the model adopted to direct the action. Besides, MSA production activities are considered to be aligned with the phases of the OODA cycle. Therefore, surveillance, recognition and compilation tasks incorporate the Observe phase of the cycle. The way data is analysed and fused belongs to the stage of Orient, and sharing and dissemination is a task contained in the Acting phase. This is considered to be the model for conducting the action of the Portuguese Navy.

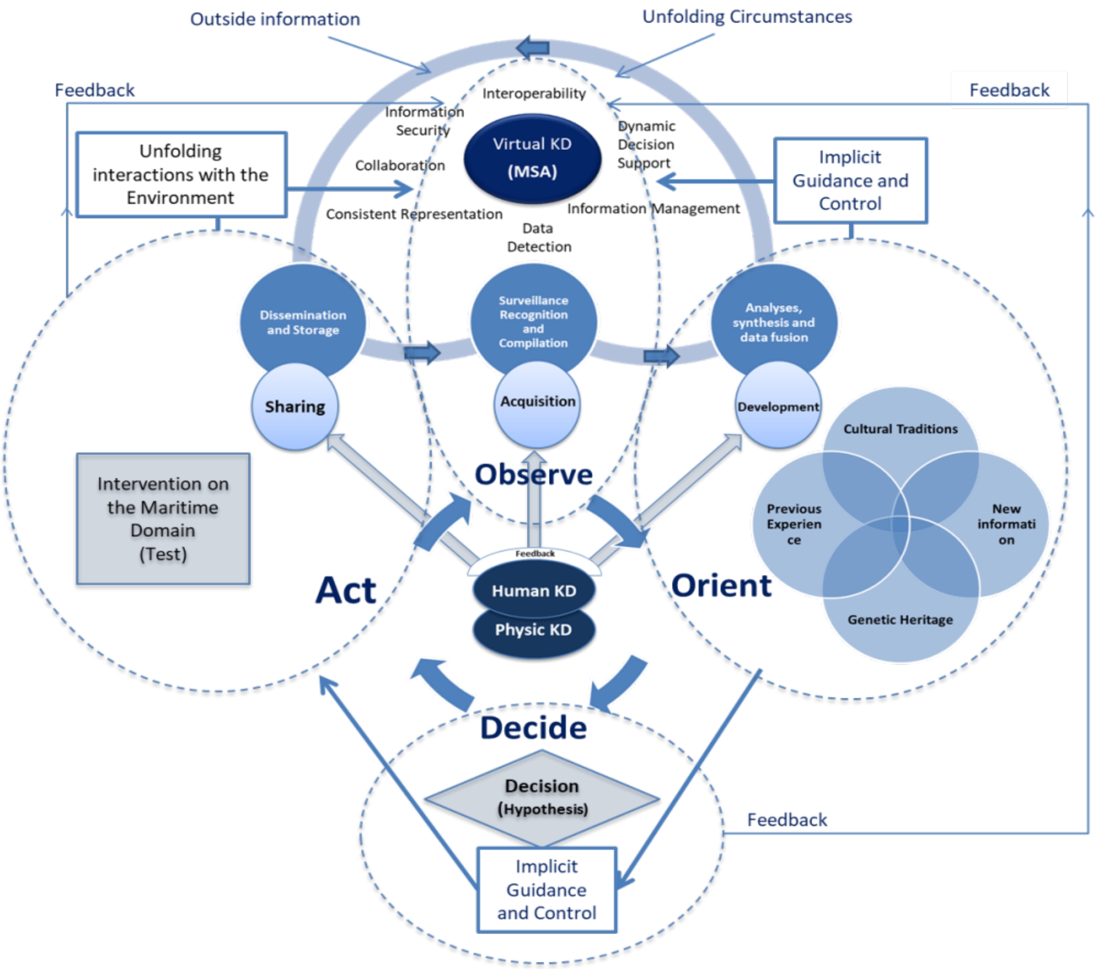

Figure 3 - Author's interpretation on Portuguese Navy construction MSA model in a decision-making environment, based on OODA loop.

ANALYSIS

It is essential to clarify that PN defines SA as a product of a set of systems, and therefore the PN is from the beginning defining a different concept from the remaining models. This PN concept is about the outcome of systems. For this model, the human interpretation of this system's output is not addressed. Figure 4 depicts an understanding of the Portuguese Navy approach on conducting the activity and MSA production, being an adapted model of the OODA loop of conducting operations in the C2 centre of maritime operations addressing MSA's construction also by the OODA loop model.

In this model, MSA's definition is considered less completed, considering the other theories presented above. It does not consider the human element in the description of MSA. Knowing the previous models, the product of a set of systems, even if they result from numerous and cyclical interactions, refinements and improvements resulting from human interaction, are not Awareness. Awareness is inherent in the individual, not in the systems. Thus, the concept of the product of a system could be, eventually, Situational Information. Even when a system predicts behaviours with more or less sophisticated algorithms, it is about a logical artefact, and Awareness only exists after this outcome being interpreted by an individual. This is the main limitation of this definition of MSA. The idea of the knowledge being separated into three domains, that the SA is created in the virtual domain, is an unusual design and not referenced. However, when considering the rest of the model, there is some logic validity due to the OODA cycle's similarity, with the respective limitations found in this model.

Although in Boyd's briefings there is a reference to the temporal question: "in order to win, we should operate at a faster tempo or rhythm than our adversaries or, better yet, get inside the adversary's Observation-Orientation-Decision-Action-loop"[33], it has been identified that the OODA cycle does not consider this factor. This simplified model to explain decision making and subsequent processes fails to suggest the importance of multiprocessing. Decision making in this model appears as a process that is always consistent with previous ones and not parallels. This model adapts to a single process circumstance without parallel phases, which

33 J. R. BOYD, «DESTRUCTION AND CREATION», in A Discourse on Winning and Losing, 1976, pp. 1–9.

raises the doubt that the model is permanently in the decision phase when applied to crises[34]. Despite its popularity in the military domain, this is considered an inconsistent model to explain human activity and even with little psychological validity. This perception is most likely because it does not refer to any cognitive process, such as attention or memory, addressing the difference between the real environment and the individual's perception of the environment and even the mental models.[35] According to Grant & Kooter, other gaps can be identified as the non-existence of the enemy or opponent element, which would be expected since this is a model drawn from this premise, an enemy's existence. This model also raises some uncertainties regarding its applicability to environments with large numbers of individuals for the same reason it was designed for the dog-fight circumstance. Although the fact that this model is widely adopted in complex environments with numerous participants, as already stated above, is a good indicator, it is not a guarantee.[36] Finally, this model does not adapt to the dynamics of groups or joint decisions. Processes such as the distribution of information, development of shared SA, redistribution of tasks, orders, authorisations, delegation are not considered for this model as seen by KEUS[37]in their SA model shared in teams, adapted from the OODA cycle.[38]

Unlike Smith & Hancock's perceptual cycle or Bedny and Meister models, Endsley's model has a better fitting. It also has a cyclical and chained structure considering the idea that the individual's perception about the environment prevails and the use of computer systems, and two additional factors: first, the Objectives and secondly the abilities, technical experience and training. These two factors have been considered essential for C2 activities and are not reflected in the PN model.

34 A. KOSKINEN-KANNISTO, «SITUATIONAL AWARENESS CONCEPT IN A MULTINATIONAL COLLABORATION ENVIRONMENT Challenges in the Information Sharing Framework Situational Awareness Challenges in the information sharing framework», National Defence University, 2013.
35 D. M. DEHN, «Private communication», Natl. Aerosp. Lab. (NLR), Amsterdam, Netherlands, 2004.
36 T. GRANT e B. KOOTER, «Comparing OODA & other models as Operational View C2 Architecture», in Control, 2005, vol. 4257, n. March, pp. 1–21.
37 H. E. KEUS, «A Framework for Analysis of Decision Processes in Teams.», in Proceedings, CCRP Symposium, June 2002, 2002.
38 T. GRANT e B. KOOTER, «Comparing OODA & other models as Operational View C2 Architecture», in Control, 2005, vol. 4257, n. March, pp. 1–21.

CONCLUSION

The requirement assessment, already conducted in 2018, identified that COMAR's central gap is the lack of data and information to detect the interaction between small vessels without Automatic Identification System (AIS) with other bigger ships, easily detectable by radar, typically with AIS near shore. That is a common factor in piracy, smuggling, trafficking and illegal immigration events. It was also identified that because of the variety of tools, agencies, organisations and systems that provide information, the COMAR needs a higher level of integration and data fusion to free operators' cognition for prediction and analysis tasks rather than focus on acquisition tasks.

The decision-making process demands novel approaches, like diversifying the data sources, such as satellite imagery, signal intelligence or even open-source information. That data is then fused, combined and processed to generate efficient services that, notwithstanding the human operator experience and knowledge, which cannot be neglected or discarded, as seen from the models above mentioned, tackles the immense needs of all the Oceans. This is done with a particular focus on the Atlantic Ocean, in which the Portuguese Navy conducts its principal operations. There is a close link between the maritime domain and all the other domains, namely, Land, Air, Cyber and Space, being the latter two transversal to all the domain to support comprehensive Maritime Situational Awareness.

It is undeniable that the mental model concept, or mental conception, is central in the individual's interaction with the environment. This phenomenon is equated in all models. In this PN model, it is concluded that mental models or schemas are not considered, but understand and address how operators produce awareness, apart from the outcome of the system, can bring benefits for the organisation.