C5ISR-D – APPLICABILITY OF THE CONCEPT IN NAVAL FORCES

Lavinia Elena TĂNASE (MĂXINEANU)
Lieutenant commander (N), Master's Degree Student, Command and Staff Faculty –
Navy Department, National Defense University "Carol I"
laviniamaxineanu@gmail.ro

Roxana MANEA (ALEXANDRU)
Lieutenant commander (N), Master's Degree Student, Command and Staff Faculty
Navy Department, National Defense University "Carol I"
roxanaalexandru23@yahoo.com

Abstract: *C5ISR is an acronym that stands for command, control, communications, combat systems, intelligence, surveillance, and reconnaissance. It plays a vital role in both combat missions and military operations by supplying real-time information to military forces so that they can make the necessary decisions while they are engaged in combat. This article aims to analyze how C5ISR systems may be effectively integrated onboard maritime platforms such as ships or submarines, including shore-based command centers, in order to enhance mission effectiveness. Incorporating artificial intelligence into the decision-making process (D), planners will be provided with optimal solutions for establishing mission objectives and priorities, as well as the most effective means of achieving them. The first aspect that will be covered, is a description of C2 architecture, which is really the foundation for C4ISR, C5ISR, and even C6ISR. Following, we connected this essential debate into a summarization of the differences between the aforementioned systems, providing answers regarding their implications, meaning, and constant upgrading. Throughout this study, after a process of data collection and analysis, we will also enumerate some of the major players in the C5ISR Market and mention a few technical systems that are already present in the maritime operational environment.*

Keywords: *C5ISR; artificial intelligence; navy.*

Introduction

The main objective of this study is to raise awareness regarding the magnitude of command and control not only as a process but also as a system. Notwithstanding the importance and practicality of technology, we also want to emphasize the relevance of humans in operating the system while also understanding the operational environment by means of a C5ISR-D system of subsystems. Using historical research, we followed the backward trajectory of technological progress and focused on the expansion of C2 architecture and framework. Also, we think is appropriate to be acquainted with the market around the systems of interest i.e., C5ISR, and the competitors that are developing them, which we managed to achieve in this article through a process of data collection and analysis.

In the records of military history, the development and the deployment of troops are two facets of the same body, and they have frequently served as a model throughout the chronicles of military conflict. For instance, the discovery of gunpowder prompted a shift in the formation of infantry phalanxes and the strategy of defending fortifications. The development of breech guns, which had the advantage of a faster fire rate, caused the formation of skirmishers as opposed to linear formations. Also, the introduction of chariots resulted in revolutionary shifts on the battlefield and so on. Many times, technological advancements and innovations have served as a source of inspiration for military commanders and staff members in the art of military application.

When considering galley warfare in terms of naval tactics, raw power determined the outcome, and maneuvering a large number of small ships was quite similar to how it was done on land. When fighting using sails, a significant deal of firepower could be concentrated

in a single ship. The tactics, maneuvering formations, and signal flags were used to coordinate and direct the wind-restricted, slow-moving formations. Later, when it came to battleships, steam power granted the ability to maneuver in any direction, and the range of the powerful weaponry allowed the concentration of fire from the entire formation. Due to the fact that strategic decisions had to be made before it was feasible to see the adversary, scouting, i.e., surveillance and reconnaissance, became an increasingly vital component of the overall strategy. The need to exercise control across much wider distances increased the number of possibilities to exploit the instruments of control. Throughout the period of the aircraft carrier and into the age of the guided missile, the tactical significance of surveillance and reconnaissance, concealment of own forces, and command and control expanded rapidly. These aspects will inquire the same level of resources and effort as armament or combat systems in order to obtain strategic or tactical success in naval operations (Hughes 1999).

The experience of past conflicts demonstrates that it is much simpler to amass knowledge than it is to disseminate it at the appropriate time and place. In the past conflicts, information perished and paled in importance in a matter of days, but nowadays, on a digital battlefield, information is rendered futile and ineffective in a matter of hours.

In conventional warfare, understanding of the information environment is becoming increasingly important. Connecting and compiling the data from all the types of the environment including the electromagnetic field, cyberspace, and geospatial field, with the data from the adversary will increase the speed of the decision-making process, thus creating the opportunity to take initiative.

The transition from C2 to C4ISR, C5ISR, and C6ISR

The concept of commanding and controlling armed forces dates back to the earliest days of battle, and that incorporates the operational planning and achievement of tasks.

The term command denotes the exercise of authority, while control, refers to exercising authority over subordinates, both being characteristics of leadership, which are also referred to as C2 in colloquial terms. According to the Allied Joint Doctrine AJP 3, C2 represents to the "*exercise of authority and direction by a commander over assigned and attached forces to accomplish the mission*" (AJP 3 – Allied Joint Doctrine for the conduct of operations, Edition C 2019). Furthermore, C2 can be split into two distinct concepts in order to differentiate the equipment and procedures used to enable C2 (command and control system), from the decision-making processes that are carried out by the commanders directly (command and control process).

The C2 process can be divided into three primary categories (Uppal 2021): *Information management*, also known as the act of acquisition of current and accurate information with the purpose of providing it to the commander to utilize in the decision-making process; *Decision Management*, judgements issued by the commander issuing sustained by the collection of information available; *Execution Management* refers to the numerous methods/ways that a commander and the armed forces use to carry out activities in accordance with decisions taken. These categories also represent the OODA cycle (Luft 2020) meaning *"Observe and Orient"* which are sections that fall under the umbrella of information management, *"Decide"* function is, evidently, a component of the decision management area, and *"Act"* belongs to the execution management.

The C2 system is a collection of technologies and procedures that commanders and staff personnel use to inform and support the command-and-control processes that are carried out during operations. Some of the fundamental attributes of the system are: *reliability* - performing tasks under the conditions imposed for a given amount of time; *sustainably* - a high level of resilience, which can survive attacks from hostile forces across the full range of

armed conflict, *adaptability* – the system is capable of adjusting to situations that undergo rapid change and can be upgradable in accordance with the advances in technology, *responsiveness* – the system is capable of providing a prompt and correct response in order to support the leadership of the commander, *interoperability* – the system and subsystems of all branches of the armed forces can work together in an integrated manner to support joint or combined operations; *friendly interface*: the commander and staff members have convenient access to information that can be used, and is presented in a way that is clear and without ambiguity.

The primary goal of the C2 system is straightforward: to fulfill the requirements of the commander in order to enable that person to exercise effective leadership. Despite what some people may believe, the system's primary focus is not on technology but rather on a wide range of other factors and considerations. Thus, the C2 system is comprised of the following four primary variables (JP3-32 2021): *Facilities and equipment*, along with command-and-control centers, servers, and workstations that enable information flow throughout the system; *Communications*, satellite, and telecommunications, which, when added to C2 framework, forms C3 (command, control, and communications). Furthermore, when computers are added to the system, the previous designation of C3 is upgraded to C4, which stands for "command, control, communications, and computers."; *Personnel*, for example, staff members who contribute to the decision-making process of the commander, and guarantee that the system's components are functioning properly; *Procedures*, that help control information, decision, and execution management.

Due to the obvious progression of technology over the years, the C2 framework has been expanded to include additional disciplines, activities, and practices.

The process of acquiring essential information that leaders and commanders must have in order to successfully complete a mission is referred to as "intelligence". As a direct consequence of this, C3I and later on C4I commenced being utilized. Furthermore, ISR is an acronym that stands for "intelligence, surveillance, and reconnaissance" which refers to the processes that are applied in order to synthesize and compile the information that has been collected. The practice of keeping regular watch over specified parts of a situation is referred to as surveillance, whereas the practice of maintaining watch over certain happenings is known as reconnaissance. As a direct result, the collective name for these types of systems is now C4ISR systems. A command-and-control center that is configured with a network connection, servers, and workstations is an embodiment of a C4ISR system. Because of these components, the center is able to interface with nearby ground, naval, and air platforms in order to acquire data pertaining to the operating environment.

ISR (Intelligence, Surveillance, and Reconnaissance) is now one of the areas that are receiving the greatest current investment in military AI. It is anticipated that the capability of autonomously collecting information using drones, from sensors in the terrestrial or maritime domain, space, and even in cyberspace, would lead to a rise in the total amount of data being created. In addition, the quantity, intensity, and complexity of the data will need to be evaluated in part or its totality by AI-enhanced machines. Due to bandwidth limits that make it impractical to send such vast volumes of data, some of that analysis will have to be done on ISR systems that have been deployed in the operating environment. No matter where it is implemented, artificial intelligence will make it possible to generate far better intelligence from the vast amounts of ISR data that are gathered.

As mentioned before, the purpose of a C4ISR architecture is to provide the common operational picture of a battlefield, the operational environment of ships, forces at sea, land, or air, or it could be a catastrophe region, among other things. This enables the mission commanders to have a clear situational awareness, which enables them to make better decisions that will benefit them to accomplish their objectives. The capacity to have a

comprehensive and superior situational awareness of the operating environment guides the commander in making effective and timely decisions, which in turn assists in effectively controlling the situation through the use of advanced planning and optimal utilization of the resources that are presently accessible.

As more sensors are deployed, C4ISR networks will be required to process an ever-increasing volume of data. The warfare is shifting, and it is projected that a far greater proportion of it will be dependent on making on-scene rapid decisions. Nowadays, due to spatial and electronic communication the process of decision-making (D) needs to be even more rapid. The advent of artificial intelligence and the associated technologies are revolutionizing the capabilities of command and control, communications, computers, intelligence, and surveillance and reconnaissance. The way wars are planned and waged will be recalibrated by the rise of artificial intelligence. In order to effectively address more integrated, conventional, hybrid, and peacetime challenges, AI systems will be indispensable.

Cyberwarfare is also redefining the architecture of the battlefield. The number of sophisticated and artfully designed cyberattacks is on the rise. Within the next several years, the next generation of military conflict will contain, on the one hand, AI-enhanced more complex C4ISR and, on the other hand, the war will be fought between autonomous machines. According to this standpoint, the opposing forces will attempt to disrupt or disable our infrastructures and systems as well as our own autonomous entities. New cyber-attack strategies will be launched and autonomous intelligent malware (Theron and Kott 2019) (AIM) will play an important role in the new landscape. This is where the fifth C comes to upgrade the C4ISR to transition into C5ISR adding cyber-defense to the already crowded system.

In the event of a conflict with an opponent that is technologically advanced, military networks will be required to operate in an environment that is heavily contested. Given that some relevant Black Sea actors have adapted their maritime strategy and used misleading strategic intentions, the adaptation of countermeasures has become a desideratum of C4ISR to transition into C5ISR. One of the Black Sea actors "*has changed its modern warfare approach by developing a new doctrine which has been tested, step by step, in the last 40 years, culminating with Crimea's annexation as a masterpiece of deception and disinformation.*" (Maxim and Scipanov 2021). Here the role of C5ISR gets its foundation. Hostile software will likely penetrate and attack friendly networks and systems. In the future operating environment, relying on human cyber-defenders to protect networks will be an unsustainable solution. Autonomous cyber defense, also known as ACyD (Theron and Kott 2019), is a comparatively new field of research and technology that is being driven by the defense industry in preparation for the possibility of future threats to military infrastructure systems and operations. Swarms of cyber defense agents that are autonomous and intelligent will be used to put an end to the threat posed by autonomous intelligent malware (AIM) within our networks and computer systems. In a setting in which there is a possibility that human intervention will not be possible due to disruptions in communication, it will be important to utilize artificially intelligent agents such as AICAs (Kott, et al. 2019) in order to remain effective in countering the adversary malware.

The construction of a comprehensive operational situation and the sharing of information through C5ISR-D architectures will provide commanders with the ability to make timely decisions. Data collected from operational forces deployed at sea, allied forces, and civilian agencies are incorporated into the C5ISR-D systems, generating resourceful intelligence that will provide commanders the ability to make timely decisions (D), while also disseminating useful necessary information such as plans, orders, or reports for the subordinate units.

Adding more equipment regarding combat systems, to the aforementioned framework C6ISR arises. An example of a C6ISR system could be a combat information center on board a warship. This center would have an internet connection, servers, workstations, and cyber defenses; all of these components would be used to assist a defense system such as the Aegis combat system (Uppal 2021).

If we were to differentiate C4ISR from C5ISR, we would point out that the second system has embedded a different kind of equipment, procedures, etc. which are linked with cyber defense. The next level of architecture would be C6ISR which adds a combat system to this array of functions. As new and developing technologies are incorporated into the C2 framework by the military, it is highly possible that we will continue to see variants of the acronyms that are linked with it. Admittedly, the C2 system needs to be adjustable to evolving changes in order for it to be upgradable with technological improvements that are generally acknowledged forefront of innovation.

Some of the functions that a C5ISR/C6ISR systems provide for naval forces are: *understanding of the operational environment – situational awareness* by providing a clear and comprehensive picture of the current state of the area of interest in real-time, using multiple sources of information (radar, optical, visual, etc.) and formats are available on a web-based platform; *information dominance –* intelligence through constant gathering and sorting the information for decision-making process throughout the operation, target management, enemy analysis; *strategic and operational planning*, the system provides authorization tools, generates the order of battle, timing all actions, etc.; *deployment,* all task units will receive mission tasks; *monitoring and assessment*, in real-time, other systems that will support information protection, encrypted communication services, etc.

In the context of military operations, "situational awareness" refers to the capability of decision-makers to process, recognize, and analyze crucial systems of information pertaining to the operational environment. Military personnel from air, ground and maritime systems will have access to real-time databases due to the improvement of technology, enabling more possibilities. When it comes to decision-making in any military action, having secure network routers, high bandwidth sensor processing, and video management systems are all extremely important components. These systems help increase the effectiveness of the overall decision-making process in military operations by presenting, handling, storing, and transmitting essential mission information. Therefore, C5ISR systems contribute to the generation of real-time data, which makes it possible to maximize any warship's effectiveness throughout any mission.

Individual navy warships of any class can be equipped or connected to the C5ISR system. Submarines, frigates, aircraft carriers, battleships, and unmanned vehicles can each be outfitted with these systems to enhance their respective roles. Unmanned maritime platforms connected to the system and able to transmit intelligent video analytics will provide over-the-horizon (OTH) mapping and targeting, therefore expanding the fleet's line of sight in all directions. The Royal Navy of the United Kingdom intends to install AI systems on its ships to better identify threats and analyze warfare scenarios. "STARTLE" machine situational awareness software from Roke Manor Research (Roke) complements existing detection systems aboard ships and delivers data-driven decisions using information obtained from those sensors. Intelligent systems powered by AI will alert other systems to possible threats, and then retransmitted to a human authority, moreover, *"these systems will recognize behavior patterns, run multi-agent-based simulations with deep learning techniques, and allow end-users to improve their Maritime Domain Awareness for rapid tasking, detecting, and tracking of non-cooperative vessels"* (Mukherjee 2018).

In recent years it has become vital to building a common operational picture in order to raise situational awareness. This can only be accomplished through the accurate and real-time

flow and sharing of data inside a C4ISR or C5/C6ISR architecture across all relevant systems in all military branches and other multinational systems.

Market of C5ISR

In 2020, the size of the worldwide C5ISR Market was estimated to be $120.3 billion, according to the meticulous study made by Research and Markets (Global C5ISR System Market 2019). Also, the findings of the study, suggest that the global market displayed an outstanding increase of 2.47 percent in 2020 in comparison to the average growth from one year to the next over the period 2017 to 2019. It is anticipated that the market would expand from a current value of 123.63 billion USD in 2021 to 152.51 billion USD in 2028, and prospects for market expansion would present themselves as a result of the increased need for space-based systems and artificial intelligence in C5ISR systems for a military operation.

The key findings of the study can be evaluated as having both positive and negative aspects regarding the way warfare is conducted today. So, even thou the C5ISR system made the contemporary warfare easier to perform, there will be a considerable financial investment necessary for the design, development, and implementation of these technologies and as a result, the expansion of the market could be restricted and it will be necessary to combine several different command-and-control systems, air defense systems, ISR systems, and other types of systems. Developing, launching, and maintaining these high-tech systems all come at a very high financial cost. In addition, the length of time and amount of money necessary for the development and implementation of this system serve as a barrier to the expansion of the market in every region of the world. The ever-growing demand for artificial intelligence in the military can be considered both an opportunity and a challenge in developing C5ISR (C6ISR) systems, combined with the reality that the development and maintenance of such systems will be highly expensive.

The competitive landscape of the market illustrates the prominence of many competitors, including BAE Systems, the Thales Group, Northrop Grumman Corporation, and Lockheed Martin Corporation, L3Harris, amongst others. These firms can be linked to a number of factors, the most significant of which include a varied product range, increased investment in research and development, and strategic acquisitions. Currently, BAE Systems has been granted a $137 million contract for lifecycle management and sustainment by the US Department of Defense, for C5ISR systems in US naval forces (Naval Technology 2022). In the meantime, over the course of the past twenty years, "*the system developers at Advanced Ground Information Systems (AGIS) have been successful in designing, developing, and delivering a Worldwide International C5ISR*" (PR WIRE India 2022) system for the military of NATO, the United States of America, and Australia.

Conclusion

The lessons learned from history have demonstrated that having efficient communication and information sharing mechanisms is just as vital as having a sound strategy and well-planned operations. The strategic importance of situational awareness has increased dramatically in recent years mostly due to the rapid progress in technologies. Big data ISR processing, advanced decision support systems (D), robotic combat vehicles in all domains, and autonomous weapons are already viable.

According to the Romanian Military Strategy (Strategia Nationala a Romaniei 2021) and Romanian Defense White Paper (Carta Alba a Apararii 2021) from 2021 one of the main national lines of effort, in the military domain, is the operationalization of the C4ISR on a tactical, operational, and strategic level. Also, when it comes to combat missions and military operations, C5ISR-D plays a crucial role by delivering real-time information to military forces so that they would make necessary decisions on the battlefield. Designing for modernization and completing

an interoperability evaluation for C5ISR both demand meticulous planning, an excellent awareness of the processes involved, and mutual engagement amongst a diverse range of stakeholders and technical fields. The construction of a comprehensive picture of the operational situation and the sharing of operational information through C5ISR-D architectures will provide commanders with the ability to make timely decisions.

Acknowledging the fact that, at the birth of algorithmic war, we must take advantage of information technology in order to enable the exchange of data between departments, different military branches, allied nations, regional allies, etc., we also have to keep in mind the potential threats of prioritizing the technology over human superior cognitive function, their creativity, agility, and social interactions. Technology can sometimes facilitate deeper integration and decision-making, while it can also overcrowd and disrupt C2.

Bibliography

Carta Alba a Apararii. 2021. https://sgg.gov.ro/1/wp-content/uploads/2021/03/CARTA-ALBA-A-APARARII (accesat 05 11, 2022).

Strategia Nationala a Romaniei. 2021. https://sgg.gov.ro/1/wp-content/uploads/2021/08/STRATEGIA-MILITARA-A-ROMANIEI-1.pdf (accesat 05 11, 2022).

AJP 3 – Allied Joint Doctrine for the conduct of operations, Edition C. *AJP-3.* NATO STANDARDIZATION OFFICE (NSO), 2019.

Global C5ISR System Market. 2019. https://www.researchandmarkets.com/reports/4807846/global-c5isr-systems-market-focus-on-platform (accesat 05 13, 2022).

Hughes, Wayne P. *Encyclopedia Britannica.* 26.07.1999. https://www.britannica.com/topic/naval-warfare/Tactics-in-the-modern-era (accesat 05 10, 2022).

JP3-32. *Joint Maritime Operations.* 2021.

Kott, Alexander, și alții. *Autonomous Intelligent Cyber-defence Agent (AICA) Reference Architecture, Release 2.0.* 2019. https://apps.dtic.mil/sti/pdfs/AD1080471.pdf (accesat 05 2022, 2022).

Luft, Alistair. *The Strategy Bridge.* 17 03 2020. https://thestrategybridge.org/the-bridge/2020/3/17/the-ooda-loop-and-the-half-beat (accesat 05 15, 2022).

Maxim, Valentin, și Lucian Valeriu Scipanov. „Considerations on the Russian doctrine for a new warfare model in the Black Sea Region." *Strategic Impact Magazine*, 2021: 66-73.

Mukherjee, Tuneer. „Securing the MAritime Commons: The Role of AI in Naval Operations." *Observer Research Foundation.* 07.2018. https://www.orfonline.org/ research/42497-a-i-in-naval-operations-exploring-possibilities-debating-ethics/#_edn28 (accesat 05 13, 2022).

Naval Technology. 06 01 2022. https://www.naval-technology.com/news/us-navy-awards-137m-contract-for-c5isr-systems-sustainment/ (accesat 05 02, 2022).

PR WIRE India. 04 01 2022. https://www.naval-technology.com/news/us-navy-awards-137m-contract-for-c5isr-systems-sustainment/ (accesat 05 10, 2022).

Scipanov, Lucian Valeriu, și Florin Nistor. „Considerations on the military actions conducted in the North of Black Sea, issue 2, no 2, pp. 99-105." *Bulletin of the National Defense University "Carol I"*, 2015, ed. 2: 99-105.

Theron, Paul, și Alexander Kott. „When Autonomous Intelligent Goodware will Fight Autonomous Intelligent Malware: A Possible Future of Cyber Defense." Editor MILCOM-2019. Norfolk, VA, 2019.

Uppal, Rajesh. *International, Defense, Security Technology.* 17 12 2021. https://idstch.com/technology/electronics/militaries-moving-from-c4isr-and-c5isr-to-c6isr/ (accesat 05 10, 2022).