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Developing a software for the analysis of METOC impact on the planning process of the maritime operations

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Abstract. Few military operations, including those of our enemies, are immune to the influence of the environment. To give the commander knowledge about the elements of the operational environment and the capability to utilize them to obtain a tactical advantage during military missions, meteorological and oceanographic (METOC) support is crucial. The next project involves creating a software that serves as an effective means of compiling METOC reports from the North-West Black Sea provided by Maritime Hydrographic Directorate in order to determine the impact of meteorological and oceanographic aspects on the maritime operations.

1. Introduction

The Services, support organizations, and other sources provide meteorological, oceanic, and space environmental parameters under the abbreviation METOC. These variables include the full spectrum of atmospheric (weather) and oceanic phenomena, spanning from the depths of the oceans on Earth to the upper atmosphere and beyond. Based on operational needs, each of the Services supplies METOC capabilities. The title "METOC" does not necessarily mean that the expert can analyze all areas of hydrometeorology. The physical characteristics of the atmosphere at a given time, the long-term climatic contexts of those characteristics, and any airborne environmental risks to activities, such as volcanic ash, dust, or icing, are all examples of atmospheric phenomena.

The physical properties of the ocean, such as waves, tides, and currents, along with chemical and biological elements (salinity, marine animals, and biophotogenesis), bathymetry, hydrography, and geophysics, are all considered to be oceanographic phenomena. Conditions and events in space and close to Earth that are often caused by solar flares and coronal mass ejections are referred to space weather phenomena. There is a difference between METOC data and METOC information. Information is created by processing data. To optimize military decision-making in operations planning, METOC information is placed in a mission-specific context using human judgment, experience, and intelligence.

In order to maintain situational awareness and ensure efficient management and distribution of information, it is crucial that the METOC specialist actively participate in the planning process and various cross-functional organizations. This is because the boundaries between responsibility and authority for the collection, production, and distribution of METOC information are sometimes overcast. The METOC specialist's proactive involvement makes it easier to deliver consistent information at all decision-making levels. The best use of METOC data is when it assists the commander in making decisions. The major responsibilities of the METOC specialist include immediate awareness of the effects of physical environmental elements on joint friendly and adversary capabilities across the spectrum of military operations, as well as current and predictive information for the commander.[1]

As a result, developing software to process hydrometeorological data is essential to make the information transfer process easier for the military operation commander. We developed a graphical user interface with which the user may identify the impact of hydrometeorological parameters on the planning of maritime operations, using the METOC database processed by the Maritime Hydrographic Directorate as a starting point. The C# programming language was used to create the application in Visual Studio, an IDE developed by Microsoft. This is a contemporary, all-purpose programming language that may be used to accomplish a wide range of activities and goals across numerous professions. Although it may be used on an open-source platform, the Windows.NET framework is where C# is most frequently utilized. This highly adaptable object-oriented programming language is relatively new to the market and offers a number of advantages, including a high level of abstraction from machine code, being close to human language, being simple to learn, well organized, and having extensive and accessible documentation for errors and syntax blunders.[2]

2. General characteristics of METOC

The METOC specialist must be familiar with all facets of the physical environment, take into account how METOC affects capabilities, and explain these consequences to decision-makers at all levels. This knowledge includes METOC assessments for both allied and enemy capabilities that are current and foreseeable, giving the commander a tactical advantage. The foundation of METOC operations is the guiding principle of accuracy, consistency, relevance, and timeliness. Planning, execution, and decision-making are supported by METOC operations when these four guiding principles are followed.[3]

2.1. Hydrometeorological principles

In order to accurately depict the state of the ecosystem both now and in the future, METOC data and information must be precise. To plan and carry out actions, the mission depends on reliable METOC information and assessments. Inaccurate data and information can result in fatalities, unnecessarily use up resources, have an impact on training, and jeopardize the accomplishment of a mission. The ability to gather fundamental METOC data in the region of interest with adequate geographical and temporal coverage to offer an accurate description of the status of the environment has a significant impact on how accurate METOC information is. The accuracy of the products emerging from hydrometeorological analysis is impacted by the constraints of METOC data gathering equipment and devices, the limitations of numerical modelling of the physical environment, human error, and the perishable nature of METOC data.[3]

The METOC specialist offers assistance in accordance with the principle of "one operation, one forecast" to enable the distribution of consistent information characterizing the status of the natural environment to operational forces at all echelons. Decision-supporting hydrometeorological data often originates from a variety of sources to assist command and subordinate elements. To guarantee that environmental data delivered to decision-makers at all echelons is geographically and temporally consistent throughout the space of interest, cooperation between the METOC elements supporting operations is necessary.[3]

The expert must understand the commander's intent and how planned actions will influence or create impacts on the enemy to achieve specified military objectives in order to produce pertinent METOC information. The METOC professional may personalize information and products by being integrated into mission decision-making so that the user can rapidly find and use pertinent information without further analysis or inquiries.[3]

The timeliness concept relies on outputs that are obtained from the most recent available data, processed, distributed, and incorporated into planning and execution processes in a timely way. The METOC expert must also be watchful and aggressive in alerting decision-makers to any changing circumstances that could have an impact on an operation.[3]

2.2. Hydrometeorological functions

- Characterization

  The capacity to gather precise data, transform it into useable information, and then construct a cogent and precise picture of the past, present, and/or future condition of the environment is known as environmental characterization. Characterizations of the atmospheric, maritime, and spatial environments that are accurate, consistent, timely, and relevant are included in collaborative planning to enable decision-makers to anticipate and take advantage of chances to plan, carry out, and sustain certain activities.[3]
- Exploitation

  Environmental exploitation entails minimizing or reducing any adverse impacts that the environment may have on friendly troops while simultaneously taking advantage of circumstances that will provide friendly forces with the greatest operational advantage over hostile forces. The efficient use of METOC data during operational planning and mission execution ensures the best possible utilization of troops, equipment, supplies, sensors, and weapons. Additionally, because almost every joint military capability is impacted by the environment in some way, it is essential for the establishment of an environmental assessment to analyse hydrometeorological consequences based on operationally meaningful METOC threshold sensitivities. Additionally, it supports and has an impact on military procedures such as planning, commander situational awareness, joint operational picture generation, command and control, and other decision-making and implementation procedures.[3]

2.3. Hydrometeorological processes

In order to take decision upon your execution of the mission, the METOC principles and functions must be considered wisely. Starting with the characterization of the environment which includes collecting the data, analyse it and predict the consequences of the actions. Tailoring all of the data, minimizing and mitigating negative effects of the environment will all conduct in making plan for dominating the enemy forces.[3]

Figure 1 METOC Processes

Source: “Meteorological and Oceanographic Operations” Joint Publication 3-59, 10 January 2018, page I-6

3. The role of METOC in mission analysis

The crew establishes staff estimates with the help of the commander's instructions, which are then utilized to influence the commander's estimate during mission analysis. The order of battle and tactics

of an enemy are taken into greater account when analysing the operational environment than their military capabilities. Instead, a given operation is significant from the standpoint of the networked systems that make up the operational environment. Analysts are helped in their investigation of the nodes in each system, linkages (relationships) between nodes, crucial components, and possible turning points by being able to identify prospective sources from which to extract indications and warnings. This enables commanders to think about a larger range of possibilities to concentrate limited resources, produce desired effects, and accomplish goals.[4]

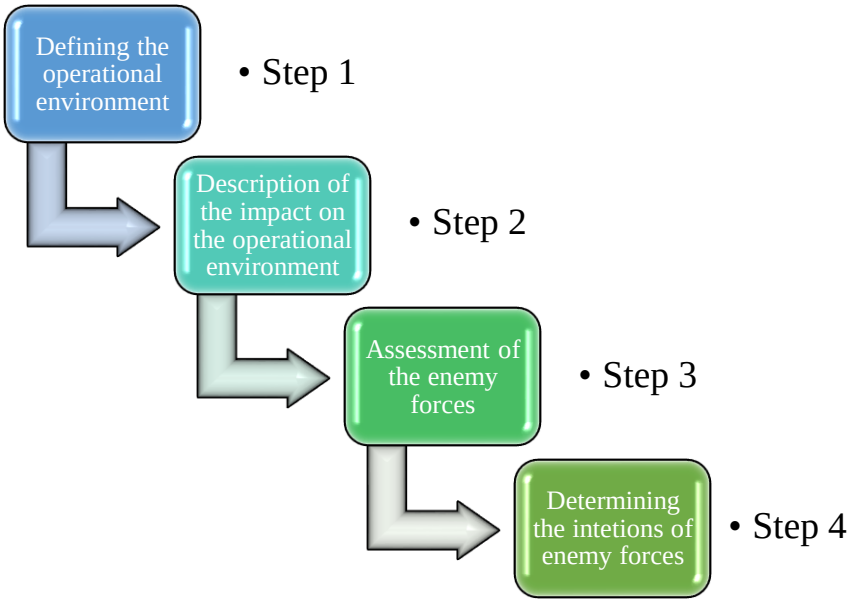

Figure 2 The process of the analysis of the operational environment

Source: JP 2-01.3, Joint Intelligence Preparation of the Operational Environment, 14 May 2014, page II-2

3.1. METOC impact on maritime operations

Hydrometeorological conditions have an effect on maritime activities. The mission concept must incorporate an evaluation of these elements, which METOC specialists must convey to the operation commander. When the mission commander informs the METOC staff about the type of mission, the time frame, and the district in which the operation is conducted, risks are recorded. The impact may be calculated using particular requirements for each mission as well as the qualities of the vessel used to carry out the marine activity. According to the traffic light model, it is presented as follows: [5][6]

- green - impact value is minimal
- yellow - impact value is moderate
- red - impact value is strong

Table 1 METOC impact

Impact	Criteria
Green	Degradation < 25-30 % or Effectiveness > 70-75 %
Yellow	Degradation = 25-30 % to 70-75 % or Effectiveness = 70-75 % to 25-30 %
Red	Degradation > 70-75 % or Effectiveness < 25-30 %.

The operation commander can extract mission-specific METOC information through machine-machine interfaces without consulting METOC personnel or knowing whether the METOC-specific information has been adapted by a specialist, in addition to manual methods of analysing METOC effects on operations. These systems can forecast weapon and sensor performance based on the effects of hydrometeorological factors on planning and execution processes. METOC personnel should be included at all stages of planning and execution since the commander might not fully comprehend the advantages and disadvantages of the information at hand. METOC physical effects in the maritime domain include:[7]

- Sea State
- Currents
- Tropical storm systems
- Acoustics (a function of temperature, pressure and salinity)

The wind-driven sea condition, which impacts safe navigation, stability for aircraft launch and recovery, and the employment of naval artillery, is undoubtedly the greatest consequence. Anti-submarine warfare also has an auditory component. Salinity, pressure, and temperature all affect sound speed. The water column's vertical and horizontal descriptions will determine how sound waves flow (bend), and these are crucial details for asset and sensor location, as well as ambient noise and bottom type.[7]

4. Developing the software

The Windows Form Application NET, a free and open-source graphical user interface class library that offers a platform for creating client applications for desktop, laptop, and PCs, serves as the foundation of the software's structure. In Visual Studio, drag-and-drop methods are used to construct forms. A dynamic application is made possible by controls because they include characteristics, event handlers, and default settings that may be changed based on the user's actions and environmental changes while the program is running. For separating the pages, we used *Tab Control* because it saves all of the values in the same form and it is easier for later usage of them. In the first page, which is called Main, the button “Start the analysis” is the one that start the program with the connection between the Form and the SOL server. Everything from the SQL Server was provided by the Maritime Hydrographic Directorate. It is important to mention that the information from the SQL Server is unclassified and throughout one year.

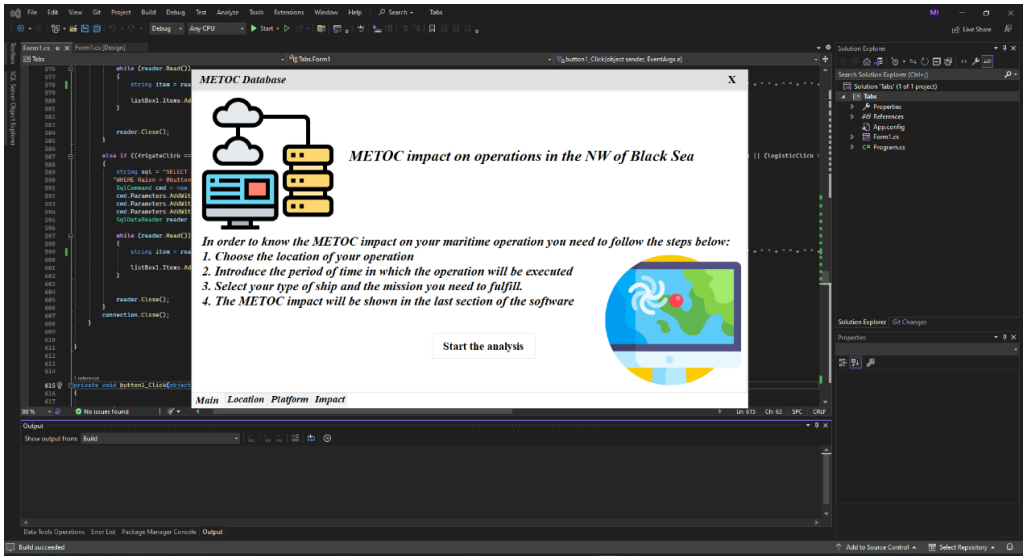

Figure 3 Main page of the Windows Form Application .NET

Source: Microsoft Visual Studio

In the second page of the Form, "Location", the user introduces the values for both of his mission's dates, start and end, and the area where the mission will be executed. The format of the period of time should be year, month, day (YYYY-MM-DD) in order to correspond with the Date column from the SQL Database.

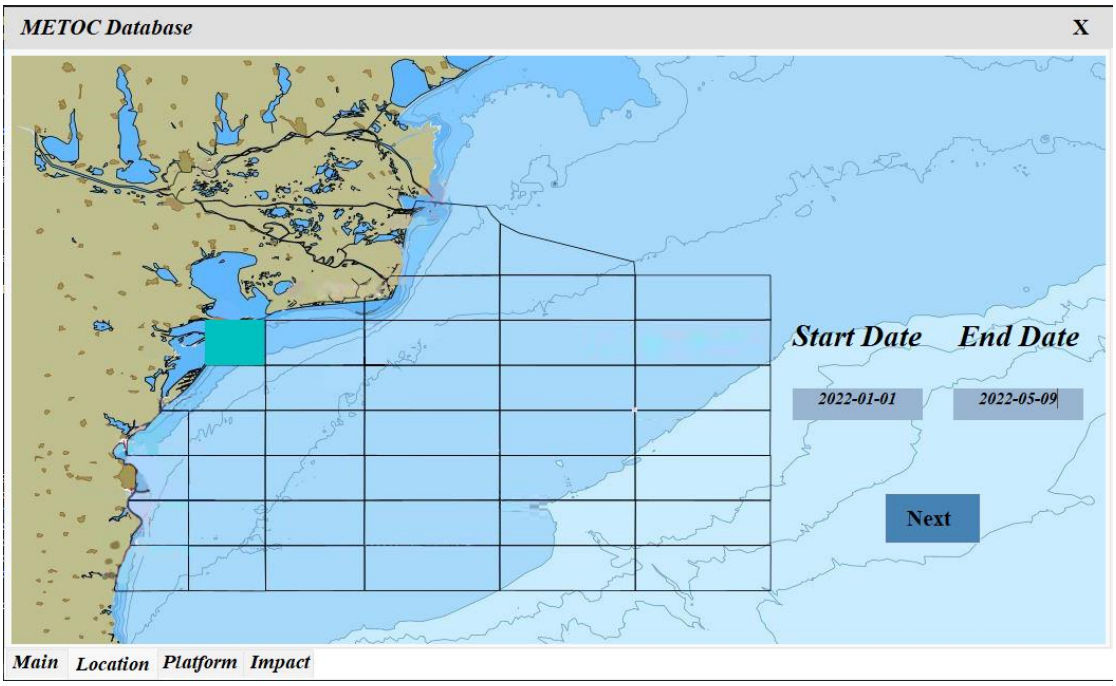

Figure 4 Location and period of time page

Source: Microsoft Visual Studio

By clicking “Next” button, the Platform page will be visible and the user has to select the type of ship from the left side panel. There are 11 buttons each corresponding to a class of ship, and this covers mainly every kind of ship that is currently in use by the Romanian Navy. When the user hovers the mouse over a button, it will be highlighted with a specific colour. After clicking the button, a list of ship-compatible operations will appear on the centre of the Form. Those are specific operations for each type of ship and is varying widely based on the primary and secondary missions that the vessels were designed for.

The final page of the software, named “Impact”, is composed of two buttons aligned in the middle of the form. After the “Show results” button is pressed, a list box containing all of the necessary data becomes visible. Each row encompasses the date with the default C# format, month-day-year (MM-DD-YYYY) and the most important part, the values for green, yellow and red sections. Those values are calculated by Maritime Hydrographic Directorate after a thorough analysis of the specific criteria. If the user wants to select another operation, the button “Clear” must be pressed in order to clear everything from the list box. After these steps, by going back to the “Platform” page the user can select again another ship and operation.

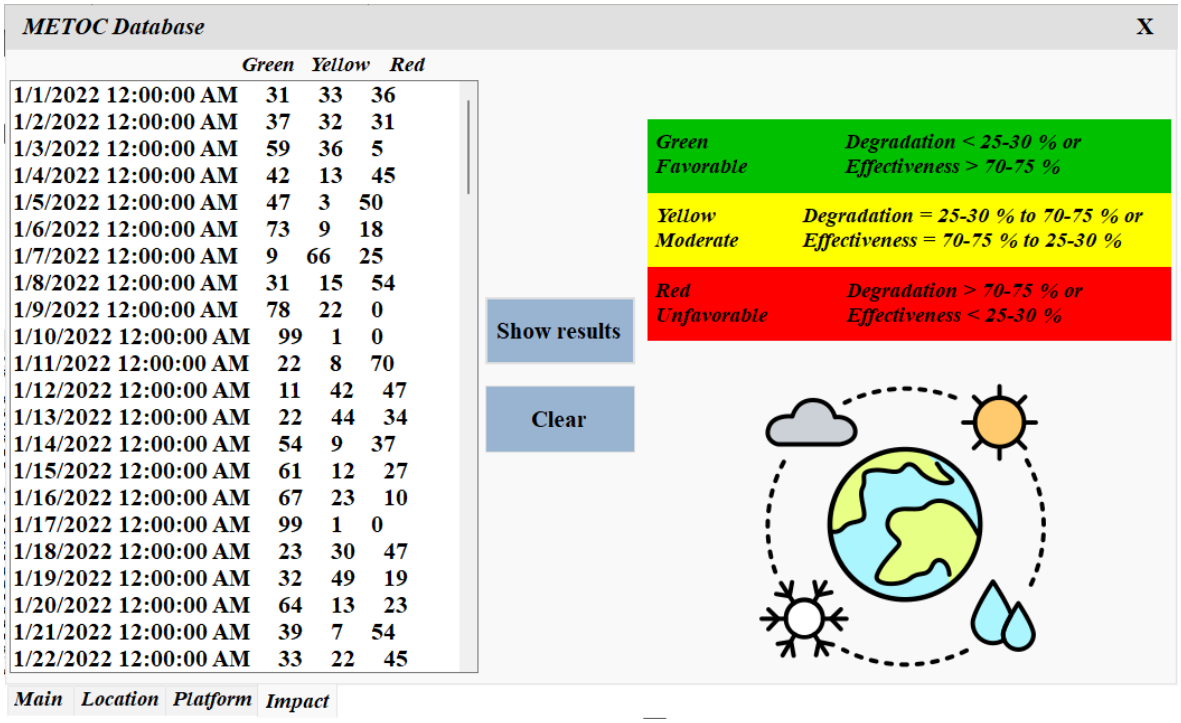

Figure 5 The Impact page of the Form

Source: Microsoft Visual Studio

The second part of the software is represented by the SQL Database in which we saved all the data from the Maritime Hydrographic Directorate. Microsoft created the relational database management system known as Microsoft SQL Server. It is a software product known as a database server, and its main purpose is to store and retrieve data as needed by other software programs. These applications may operate on the same computer or on a different machine connected to a network (including the Internet). Microsoft offers at least a dozen distinct editions of SQL Server that are targeted at various clienteles and can handle workloads ranging from modest single-machine programs to huge Internet-facing programs with several concurrent users. [8]

The columns from the database are Area, Date and the impact (green, yellow, red). Maritime Hydrographic directorate evaluated 11 criteria in which all the operations and ships are included. The reason of organizing the database in this way is that the whole information processed by their software occupies a lot of memory and usual computers can't handle the whole database.

5. Conclusions

Military operations are impacted by weather and oceanographic conditions, which have various impacts on the type of forces and, in certain situations, can dictate the types of forces that can be utilized efficiently. Commanders who are responsible for planning and carrying out operations need a variety of information, including METOC data. This data comes from the evaluation of hydrometeorological parameters, identification of weather impacts, and analysis of weather data to give commanders crucial data for the most effective use of troops. All different kinds of naval force activities may be impacted by the weather and shifting oceanographic processes. Each level of command has a variety of duties and responsibilities as well as specific needs for METOC information and assistance. All must be supported by METOC activities, goods, and services.

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References

[1] “Meteorological and Oceanographic Operations” Joint Publication 3-59, 10 January 2018, Chapter I page 1

[2] https://learn.microsoft.com/en-us/dotnet/csharp/tour-of-csharp/ , accesed at 03.05.2023

[3] “Meteorological and Oceanographic Operations” Joint Publication 3-59, 10 January 2018, Chapter I page 2-9

[4] JP 2-01.3, Joint Intelligence Preparation of the Operational Environment, 21 May 2014, Chapter 2, page 1-8

[5] U.S. Joint Forces Command “Joint Meteorology & Oceanography (METOC) Handbook”, 4th Edition 1 April 2002

[6] U.S. Joint Forces Command “Joint Meteorology & Oceanography (METOC) Handbook” 1st JMOC Edition, April 2011

[7] U.S. NAVY NWP 3-59M, U.S. MARINE CORPS MCWP 3-35.10 “Operational Level Integration of METOC Capabilities”, Edition December 2013

[8] https://en.wikipedia.org/wiki/Microsoft_SQL_Server accesed at 01.05.2023