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Modelling of navigation and hydrometeorological conditions in the coastal and harbour area Constanta – Agigea

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Abstract: The success of the ship's voyage depends on accurate and up-to-date meteo-oceanographic information about the sea areas crossed. This article demonstrates the benefits of establishing routes appropriate to the knowledge of the actual meteo-oceanographic conditions, which will ensure: time and fuel savings, increased safety of the vessel, crew, and mission success. The modelling of navigation and hydrometeorological conditions in the coastal and harbour area of Constanta Agigea is necessary to know the efficient execution of the voyages of an integrated multi-sensor maritime platform, intended for real-time intervention for disaster risk management in Romanian coastal and harbour areas.
Keywords: PLATMARISC project, Romanian coastal area, oceanographic data, multi sensor maritime, platform

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1. Introduction

Oceanographic research provides knowledge at a high scientific level of the physical, chemical, geological and biological phenomena and processes that occur interdependently in the marine environment and in the atmospheric layers above the planetary ocean: waves, storms, precipitation, currents, the nature of the seabed, marine fauna and flora, the chemistry of marine waters, etc [1].

Modern ships are equipped with meteo-oceanographic instruments and observation equipment which, together with adequate knowledge of marine meteorology and oceanography, provide the knowledge and understanding of the marine and underwater environment necessary for safe, time-saving and successful navigation.

Nowadays, it is no longer possible to conceive of a ship's voyage without accurate and up-to-date weather and oceanographic information on the maritime districts crossed. The study of numerous sea and ocean crossings shows the advantages of establishing routes that are appropriate to the knowledge of the actual meteo-oceanographic conditions, which ensures: time and fuel savings, increased safety of the ship, crew and success of the mission [2].

For marine navigation, these include: temperature, salinity and density of seawater, sea currents, waves, hula, as well as chemical oceanography, marine biology and marine ecology.

The sea has the appearance of a deep basin, oriented from west to east, stretching about six degrees of latitude and about five degrees of longitude, between parallels of latitude 40^0 55'N and 46^0 37'N and meridians 27^0 27’E and 41^0 47’E. It is an intercontinental sea, connected through the

Bosphorus Strait to the Mediterranean Sea and through the Kerch Strait to the Sea of Azov. The Black Sea is an area with its own specific characteristics. The surface area of the Romanian coastal zone represents 6.5% of Romania's territory and the length of the coastline (245 km) 7.6% of the length of the Romanian borders. The Romanian coastal zone comprises: inland waters; territorial waters (12 nautical miles); contiguous zone (12 nautical miles), exclusive economic zone (incompletely unregulated in the Black Sea). In the north-western part of the Black Sea the continental shelf is predominant, representing an area of about 127,000 km2, i.e. 94% of the total shelf and 30% of the total area of the Black Sea; the volume of water above this shelf is about 6,500 km3 about 1.2% of the total volume of water in the Black Sea. The main rivers of the Black Sea basin: the Danube, the Nistru, the Nipru and the Southern Bugul, flow into this basin. The Danube plays the predominant role in the sediment transport process in this part of the Black Sea (with effects as far as the Bosphorus and in areas with large depths), while the Dniester, the Nistru and the Southern Bug have a secondary role (sediment transport in lagoons).

Very important for technological activities, navigation and shipping in the Black Sea are waves, wind and sea state. These can have a direct, negative, strong and even dangerous effect on ships at sea and on hydrotechnical constructions. Wind waves are highest in winter and autumn, when offshore winds predominate. In the western Black Sea basin, the height of these waves is 6 to 8 m, with a maximum of 14 m. On the shore, the value of these waves varies, for example, from 4.3 m at Odessa, 5.7 m at Sevastopol, 6 m at Constanta and 8 m on the mountainous shores. Strong waves occur during the cold season (10% frequency in some districts) and less frequently (3%) in the summer. Periodic, particularly strong storms, especially in the cold season, have caused considerable material and human losses, including on the Romanian Black Sea coast [3].

The meteorological character of the maritime coastal area of the NW Black Sea is directly influenced by the vicinity of continental Dobrogea and by the specific action of meteorological factors in the Black Sea basin. The existence of the Black Sea and the Danube, with a permanent evaporation of water, ensures the humidity of the air and at the same time causes the regulation of its warming.The average annual temperatures are higher than the average for the country (e.g.: 11.2^0 C in Mangalia) [3].

2. Data and methods

For the modelling of navigation areas and hydrometeorological conditions for the use of the maritime platform, were used the ANMB Integrated Navigation Simulator facilities. The Integrated Shiphandling Simulator is composed of two main modules, oriented to both the shiphandling and navigation elements (Navi Trainer Professional (NTPRO) 6000 navigation and shiphandling module).

The entire system is certified by DetNorske Veritas and Nippon Kaiji Kyokai for Class A simulators, a class in which are classified top products in terms of facilities offered. The entire complex is served by 110 computers with an installed computing power of 71 kW. The ship navigation and manoeuvring simulator consists of a Server (Domain Controller), two instructor stations, a Navi-Trainer Model station, 11 navigation decks and a briefing room, where 11 ships can be simulated simultaneously on different types of consoles in different areas of the complex (one main compartment with a 240° panoramic projection screen, one intermediate compartment with a 120° panoramic projection screen, three compartments with 90° projection screens and 6 virtual consoles). The simulator allows to practise manoeuvres with various types of ships, both military and civilian (2 types of general cargo ships, 10 container ships, 1 yacht, 3 oil tankers, 1 liquefied petroleum gas carrier, 2 types of passenger ships, 1 tugboat and 5 types of military ships).

To realise different discipline-specific exercises, the Ship Navigation and Manoeuvring Simulator "Navi-Trainer Professional 6.0" offers a wide range of capabilities available to instructors, such as: 25 own ships, 26 navigation areas (electronic charts), 416 target ships and other modelling software solutions. One of the novelties of this new generation of simulators is the special attention paid to the mathematical modelling of ship behaviour at sea, weather and hydrological conditions, as well as to the simulation and modelling of the specific operations performed [4].

The modelling steps consisted of the following objectives:

1. Identification of the probable navigation areas of the maritime platform equipped by the economic agent COREMAR SA.
2. Identification of the navigation charts for the action areas.

3. Setting the navigation equipment on board the offshore platform.
4. Input the ship model with technical and operational characteristics into the simulation.
5. Checking the settings for simulating hydrometeorological conditions in the navigation areas suitable for this offshore platform.
6. Verification of the settings related to hydrographic conditions (depths, nature of the seabed, hydrotechnical constructions, navigation signalling, etc.) in the navigation zones of interest.
7. Simulation of the evolution of the model ship in the set areas under different navigation and hydro-meteorological conditions.

After modelling, in the following stages of the project, the correlations between the simulated behaviour of the vessel and the intervention scenarios will be carried out, in the situations foreseen in Activities 1.7 and 1.8 of the PLATMARISC project [5].

3. Results and discussions

Following the modelling activities, were achieved the following:

a. Identification of the probable navigation areas of the maritime platform equipped by the economic agent COREMAR SA. The probable areas of action of the model ship were identified to be:

- Port of Constanta, with mooring berth (Figure 1):

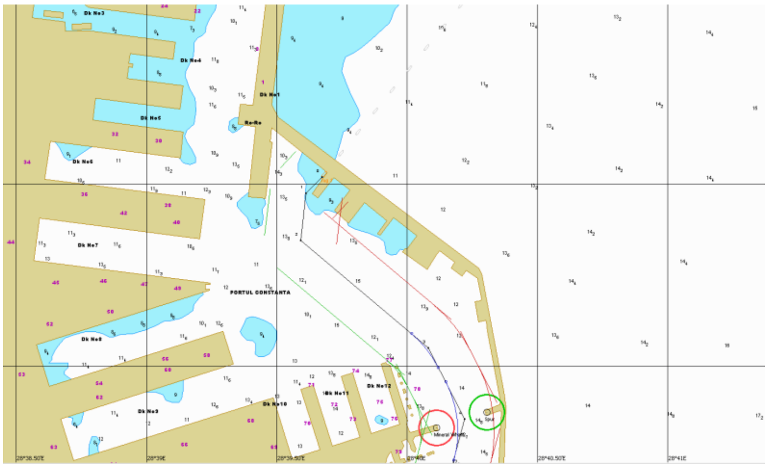

Figure 1. Port of Constanta, with mooring berth

- the exit from the Port of Constanta (Figure 2):

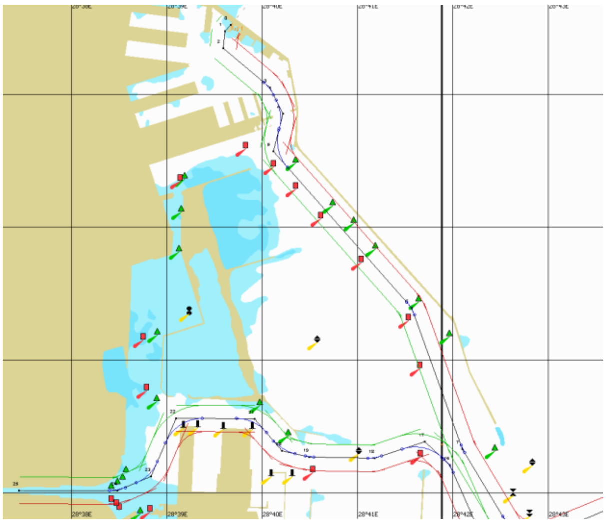

Figure 2. Exiting the Port of Constanta

- Constanta north navigation area, with Constanta roadstead and Constanta south navigation area, with access to Constanta south port - Agigea, Danube - Black Sea Canal (Figure 3):

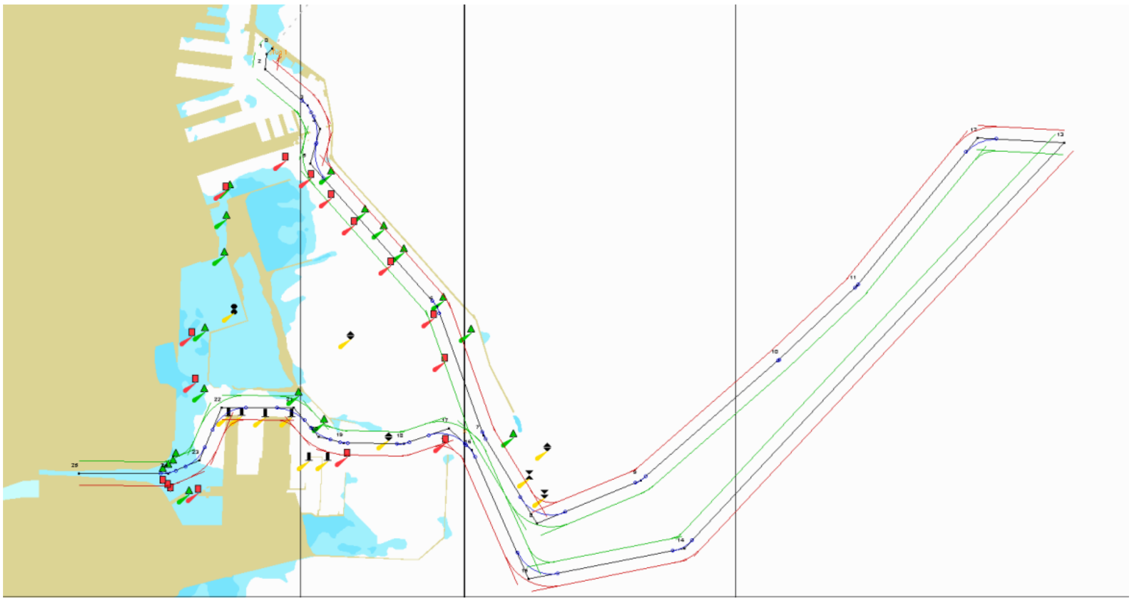

Figure 3. Navigation area Constanta north, navigation area south Constanta south

- Agigea harbour navigation area, with the position of the future working point, at Agigea, of the economic agent COREMAR (Figure 4):

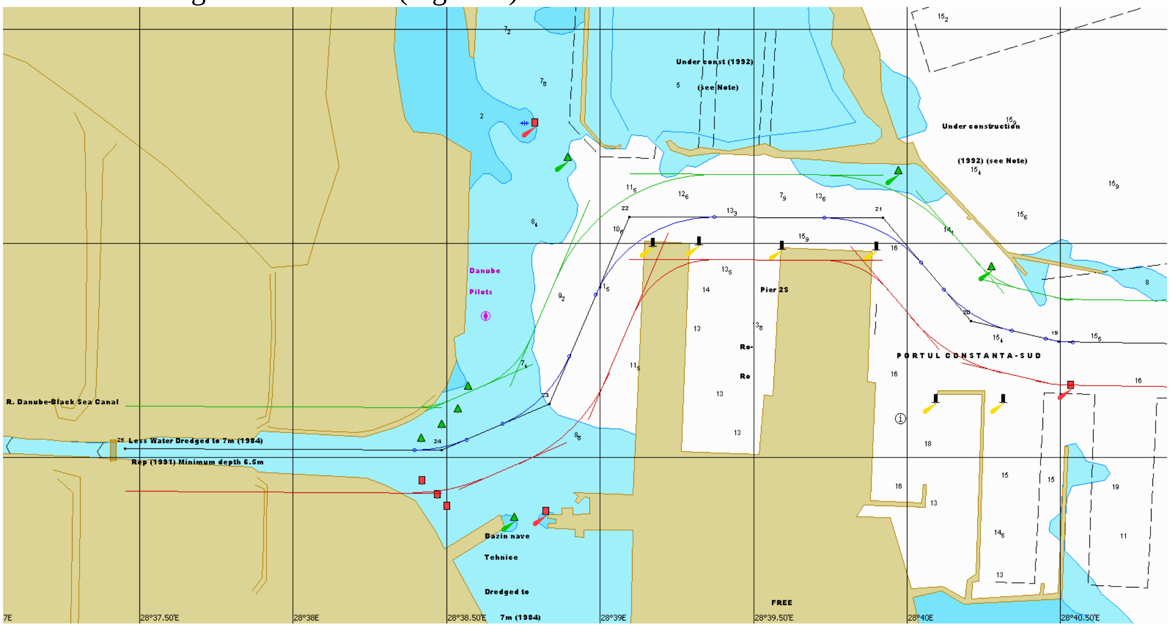

Figure 4. Agigea harbour navigation area

b. Identification of the navigational charts of the respective areas.
The following navigational charts have been identified for use by the model maritime platform in the Black Sea (Table 1):

Table 1. Navigational charts to be used by the model offshore platform in the Black Sea

Chart no.	INT	Chart name	Scale
1.300.01	INT3820	Black Sea. Coast of Romania. Nos Kaliakra to Delta Dunării	300.000
1.250.01		Marea Neagră. Coasta României. De la Nos Kaliakra la Braţul Chilia Cartuşe: A Portul Constanţa. Zona Midia B Portul Constanţa C Portul Mangalia	250.000 50.000 50.000 50.000
1.150.01		Marea Neagră. Coasta României. De la Nos Kaliakra la Vadu	150.000
1.150.03		Marea Neagră. Coasta României. Delta Dunării	150.000
1.100.02		Marea Neagră. Coasta României. De la Mangalia la Portul Midia	100.000
1.100.03		Marea Neagră. Coasta României. De la Portul Midia la Sacalin	100.000
1.100.04		Marea Neagră. Coasta României. De la Sfântu Gheorghe la Braţul Chilia	100.000
1.075.01		Marea Neagră. Coasta României. De la Vama Veche la Capul Midia	75.000
1.075.02		Marea Neagră. Coasta României. De la Capul Midia la Gura Portiţei	75.000
1.075.04		Marea Neagră. Coasta României. De la Sacalin la Bîstroe Gîrlo	75.000

c. Setting the navigation device

During the simulations, were set operating data for navigation equipment, such as: navigation radar, autopilot, electronic maps, communications, etc. ARPA type navigation scale with: 10 scales in the 0.125 - 96 Mm range; minimum detection range: 25 m; position accuracy: less than 1°; distance accuracy < 1% on scales greater than 15 m, whichever is greater; display current cursor position, latitude and longitude; Image presentation: "Head-up", "North-up", "Course-up"; "Clutter" reaction (attenuation of waves and noise): presentation of semi-automatic action for display optimization, interference reaction; guarded area; modde prezentare day and night; AIS interface included; automatic plotting minimum 100 targets. Autopilot connected with gyro and magnetic compass and in combination with a route planning system (ECDIS/GPS). The automatic pilot adjusts the ship's speed according to the sailing conditions in order to avoid a large drift on the set course. At the same time, it sounds an alarm to announce navigational changes that are underway. The ECDIS system of electronic charts that displays over the maps image; possibility of simultaneous display of vector maps and radar maps; continuous monitoring of ships in raport with a planified navigation route; record and resume navigation route; navigation route planning and validation; display at least 50 targets; display target APPA/ATAA; display target and information on AIS; real-time display of the ship's position and avoidance of recirculated areas; Manover board function; NMEA interface and LAN gyrocomras /GPS, AIS.

d.Introduction into the simulation of the ship model with the following technical and operational characteristics: intervention platform with dimensions appropriate to its intended purpose, capable of navigating safely in various hydro-meteorological conditions. Main construction dimensions of the vessel are: length 29 m; width 13 m; draught 5,90 m; gross tonnage max. 490 t; bollard pull min. 60 TBP; propulsion system with a minimum power of 4.800 hp; radar navigation equipment, GPS receiver, compass, etc., in accordance with the class requirements for "Unrestricted navigation".

e. Check settings for simulating hydrometeorological conditions (Figure 5 and 6):

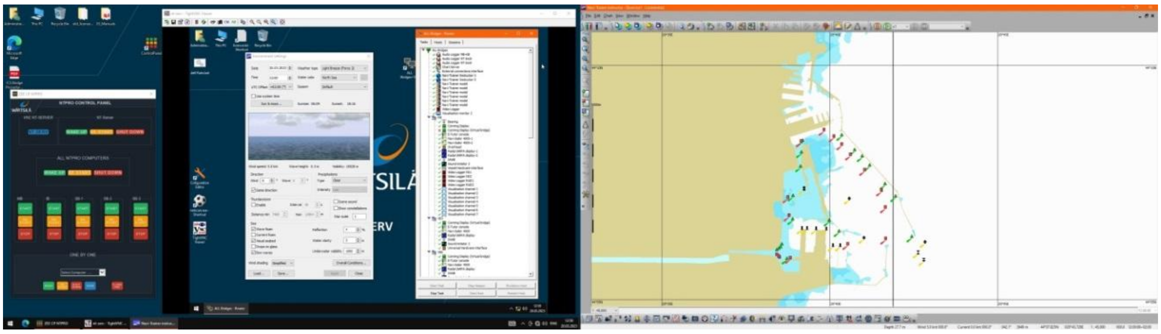

Figure 5 Modelling hydrometeorological conditions

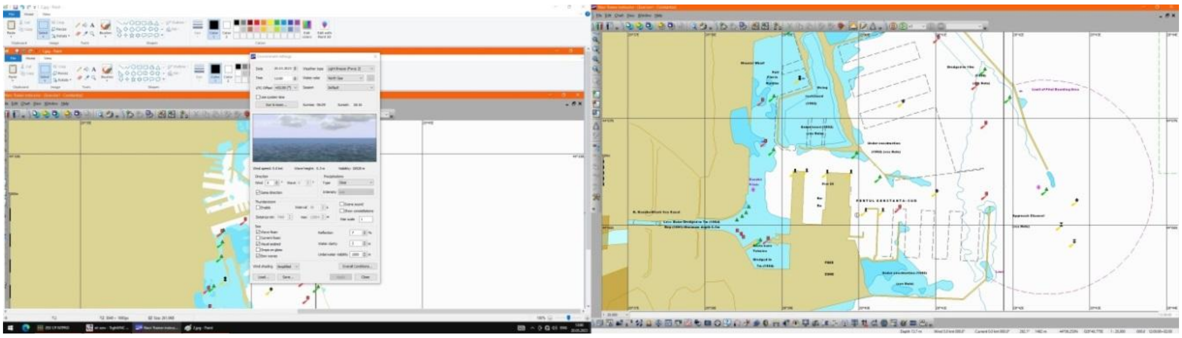

Figure 6 Modelling hydrometeorological conditions

f.Check settings related to hydrographic conditions (depths, nature of the seabed, hydrotechnical constructions, navigation signalling, etc.).

The hydrographic conditions specific to the coastal navigation area Constanta - Agigea were set: depths, nature of the seabed, hydrotechnical constructions, navigation signalling, etc. (Figure 7).

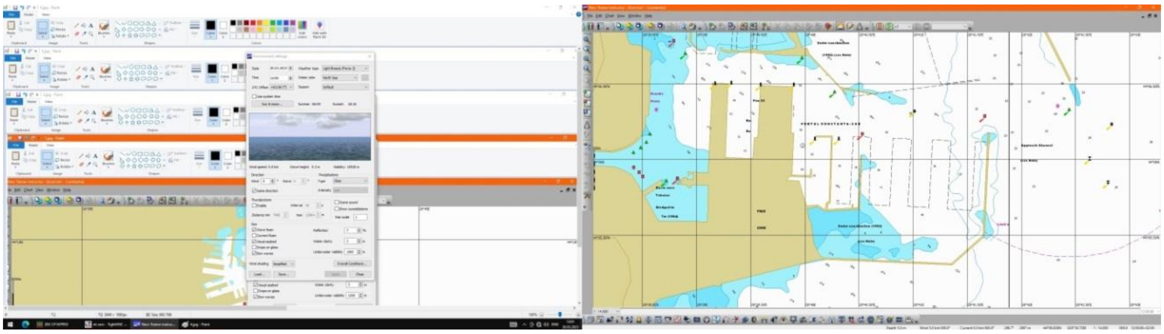

Figure 7 Hydrographic conditions specific to the coastal navigation area Constanta - Agigea

g.Simulation of the evolution of the model seabed in the set areas, under different navigation and hydro-meteorological conditions from calm sea to sea degree 4-5 (Figure 8, 9, 10, 11, 12).

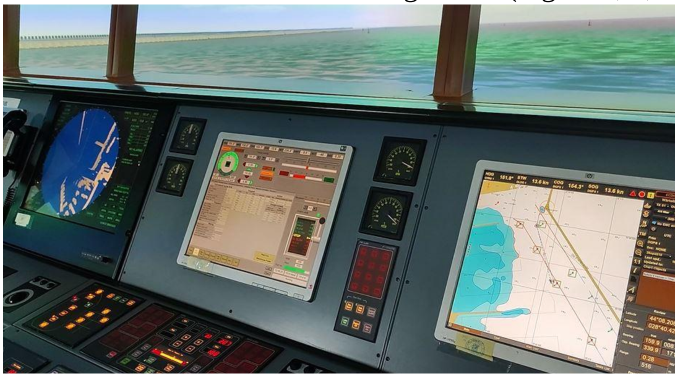

Figure 8 Simulation of the evolution of the model seafloor in the 0 degree sea

Figure 9 Simulation of the evolution of the model seafloor in sea level 1-2

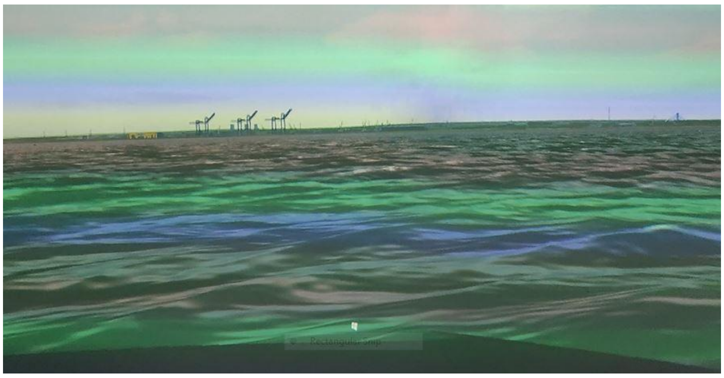

Figure 10 Simulation of the evolution of the model sea shelf at sea level 2-3

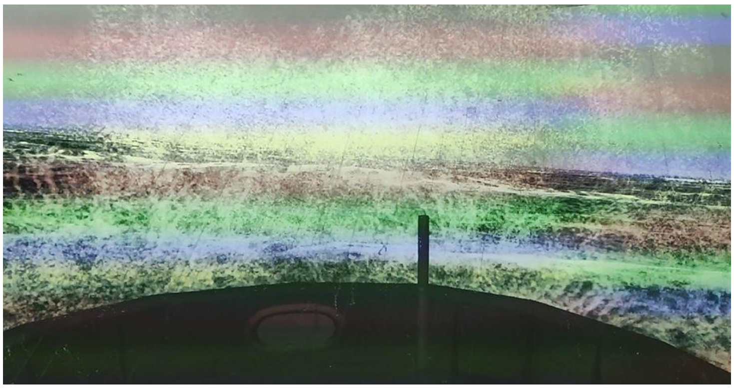

Figura 11 Simulation of the evolution of the model seafloor in sea level 3-4

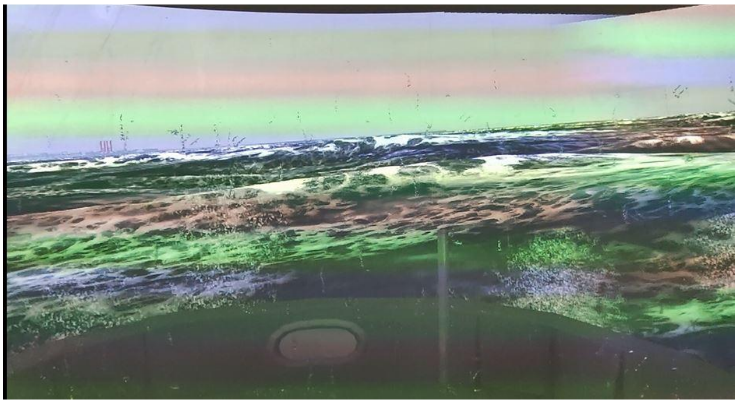
Figure 12 Simulation of the evolution of the model seafloor at sea level 4-5

4. Conclusions

Modelling navigation and hydrometeorological conditions in a coastal and harbour area is a complex activity requiring the action of a multi-disciplinary team of specialists. The modelling of navigation and hydrometeorological conditions in the coastal and harbour area of Constanta - Agigea has been carried out in order to understand the action and response of a maritime platform intended for real-time intervention through simulated assistance in disaster risk assessment and reduction in support of coastal maritime towing for special situations. The Integrated Navigation Simulator of the Naval Academy "Mircea cel Bătrân" Constanta provides the hardware and software framework for a first modelling of the action areas of the maritime platform, the hydrometeorological conditions here and the evolution of the ship under these conditions. The modelling thus achieved constitutes the theoretical basis for the successful continuation of the following activities within the PLATMARISC project.

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