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Feasibility Sheet for the Program The Maritime Technological Surveillance carried out through Sensor Networks based on Fixed and/or Semi-fixed Unmanned Platforms

By Dr. Diego Abbo

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$$Tm >> Ta + Ti$$

Dove:

Tm: It represents the time it takes for the threat to complete its mission.

Ta: It represents the alert time in which you are aware that the threat is completing its mission;

Ti: It represents the time to engage the threat before it has completed its mission.

The times indicated (Ta and Ti) can be represented in naval scenarios with the triangle DPE (Detection, Positioning and Engagement).

The DETECTION in the present case indicates the discovery but not the location (POSITIONING) which may or may not be followed by subsequent locations in a tracing eventuality.

The last certain position of the target is defined, in the air and naval field, as DATUM.

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Feasibility Sheet for the *Program* The Maritime Technological Surveillance carried out through Sensor Networks based on Fixed and/or Semi-fixed Unmanned Platforms

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I. Premise

The safety in general which includes those of the maritime areas of interest must satisfy the principle of the so-called safety equation:

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In the current geostrategic scenario, the threat must only be seen in a direct war confrontation. In the other sense the target, in the DPE Triangle, enlarges the concept threat. In fact, in the rescue missions of human life at sea the threat must be understood only as the impediments to act to complete the rescue.

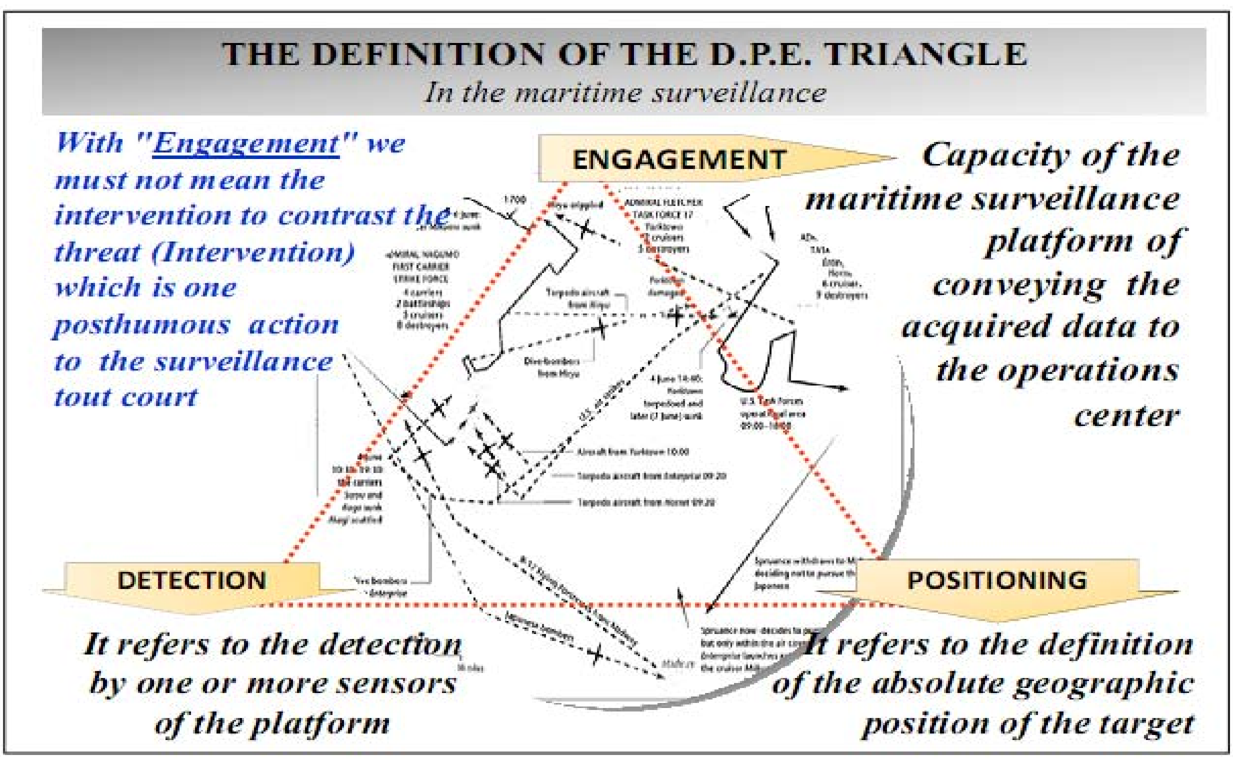

Figure 1: The image refers to the battle of Midway (4÷7 June 1942) where the two opposing fleets never came into direct contact but the victory of the USA was made possible by the parameters of the D.P.E. in force at that time

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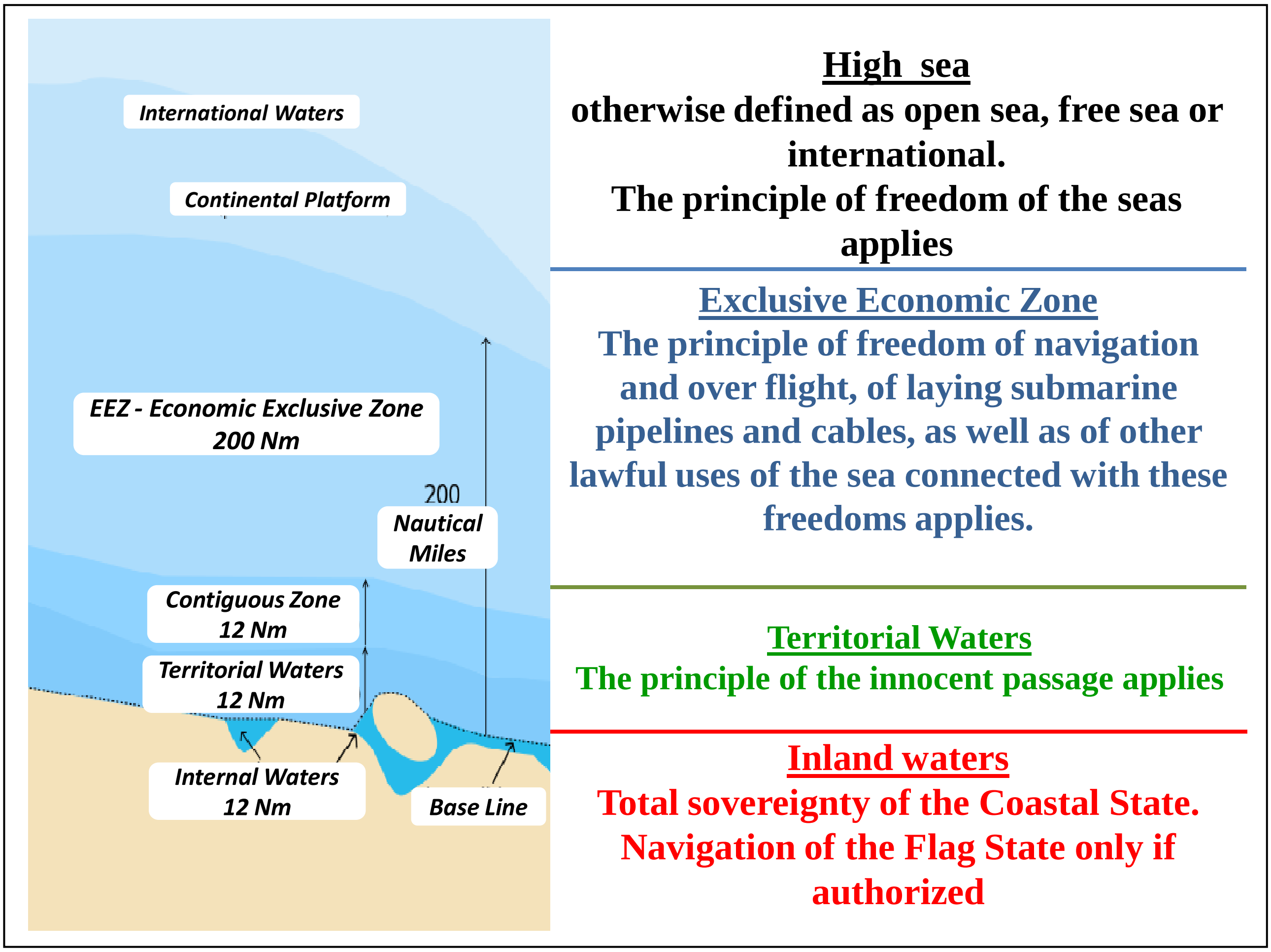

Figure 2: The subdivision of the sea according to the Montego Bay Convention

Therefore ENGAGEMENT has considerable diversifications according to previously planned needs.

The mission of maritime surveillance therefore relates to the discovery and localization with the related *Ta* and *Ti*.

Therefore, the optimal surveillance is reached when, in the area of interest, there is a total geographical coverage of the DPE Triangle parameters for 24 hours a day and 7 days a week.

II. The Sea Arena

The global maritime surface is divided into legal zones in which the duties and rights of the States, that have cause, are established according to the Montego Bay Convention (UNCLOS - *United Nations Convention on the Law of the Sea*).

In the following Figure 2 the areas in question are identified and each one corresponds to a comparison matrix between the rights/duties of the coastal and flag states respectively.

In the current maritime scenario, surveillance in the Exclusive Economic Zone (EEZ) highlighted in Figure 3 according to a vertical elevation has a particular value.

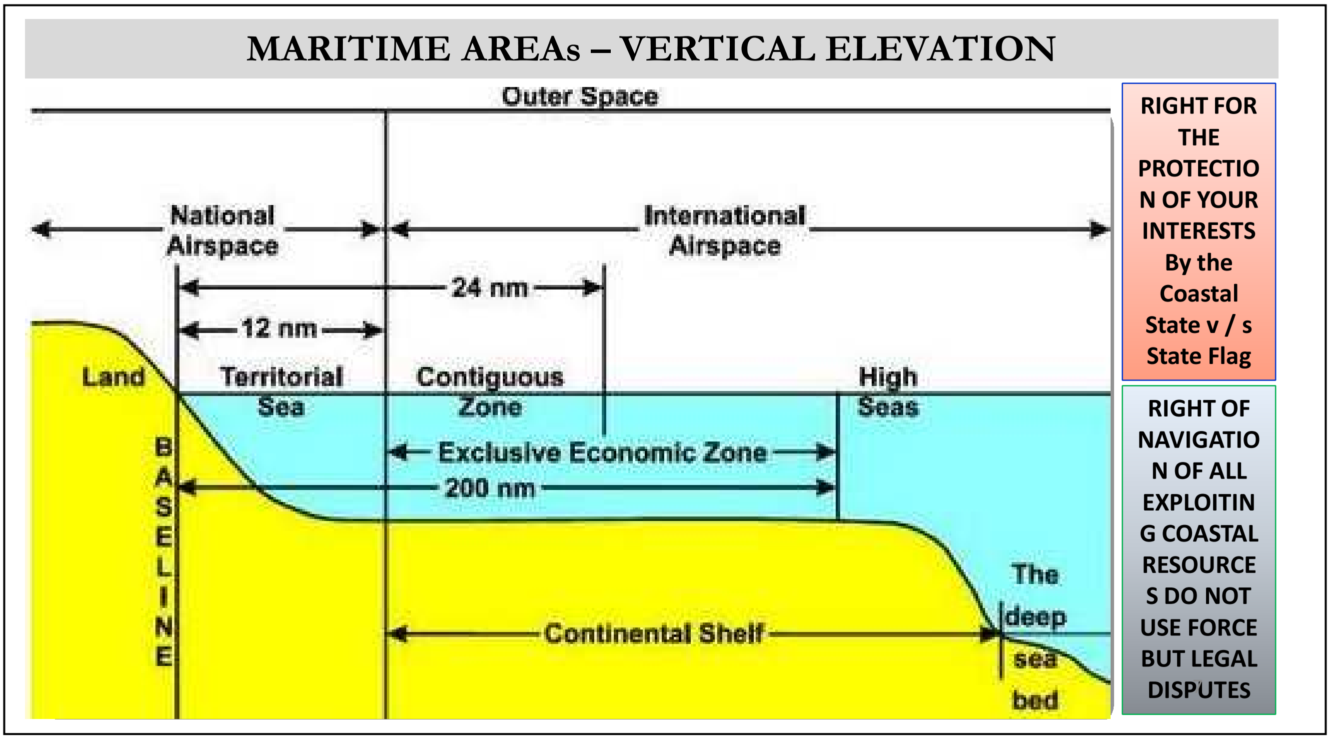

Figure 3: The vertical elevation of the maritime areas of UNCLOS

Figure 4 highlights the probable EEZ of Italy at the end of its determination by the Italian Government.

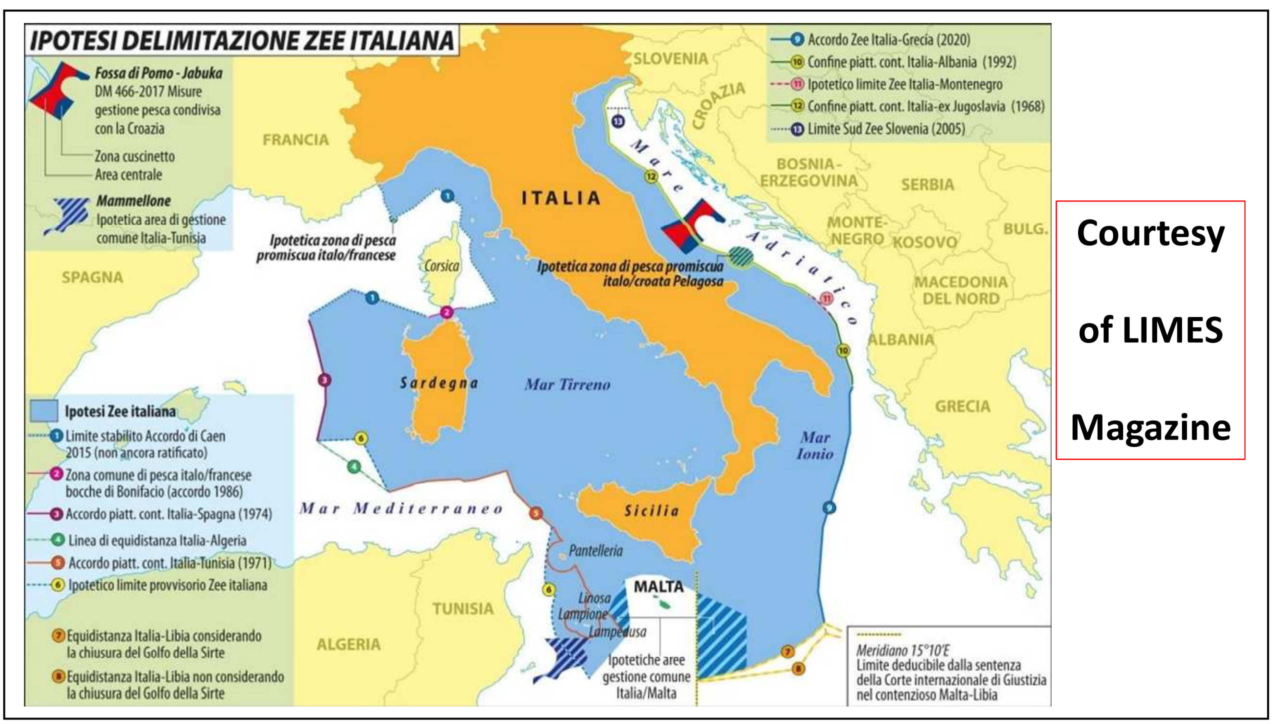

Figure 4: The possible ZZE of Italy at the end of the parliamentary process underway for its determination

The coastal state, while having to guarantee the freedom of navigation and over flight of the flag states, has the exclusive ownership to establish platforms for the exploitation of resources relating to both the water column and the seabed.

In the specific case, Italy should guarantee freedom of navigation in the EEZ but should also protect all commercial platforms producing renewable energy and exploiting the resources of the seabed and the overlying water head.

The point is the preventive defense of national maritime interests with a capillary surveillance system that adopts various forms and levels of technology.

The current systems used in the EEZ are not unmanned fixed platforms but are aircraft (unmanned or manned) used for surveillance which, due to costs, does not satisfy the requirement of continuous stay on site.

Furthermore, they are unable to satisfy the need for knowledge and awareness of the maritime situation in order to exercise their direct control or sovereign authority over the low-cost, low-manned territory of interest.

There is therefore a need for a new type of strategy based on newly developed resources, one that can take advantage of remote decentralized distributed sensors and network architecture of the type C3 (Command, Control and Communications), which is able to reduce the need to deploy high-value manned resources to perform maritime surveillance and to provide persistent and permanent awareness of the entire maritime situation.

The proposed type of resource will be able to host existing and emerging sensors and other required technologies in a cost-effective and operationally robust way.

A fundamental requirement for this new type of resource is to be able to carry out long-range maritime surveillance and projection towards the sea.

Furthermore, this type of resource or asset will be of the floating type, therefore semi-fixed, able to be redistributed and therefore reconfigure the spatial arrangement of the network within the national offshore areas of interest.

The platforms aimed at the purpose and therefore proposed are the following:

- BUOY not anchored (to be redeployed)
- Anchored larger BOA (to be redeployed)
- Instrumented platforms to be associated already existing on site or possibly to be deployed;
- Dedicated wind turbines;
- Oil platforms already existing on site.

The aforementioned platforms must be such as to be able to carry radar systems, ESM systems, sonar and hydrophone systems, electro-optical detection devices, magnetic anomaly detectors and particular systems of both communication and specific power supply aimed at the platform.

For structures dedicated to wind turbines or oil platforms, the possibility of docking various types of "unmanned" platforms (UxVs) will also be provided.

Current technologies, enslaved by renewable energies geared towards miniaturization, can provide a very profitable scenario solution.

However, these solutions must have optimal integration on satellite coverage and those provided by on-site platforms.

III. Buoys not Anchored and Anchored

The buoy that is not anchored is of minimal size and left adrift at sea after being placed on it, on contingency needs, by fast aircraft or ships.

The purpose of the buoy or network of unanchored buoys is to contribute to Maritime Surveillance in order to saturate the area of interest.

The buoy structure must be able to appropriately embark the various sensors aimed at maritime surveillance.

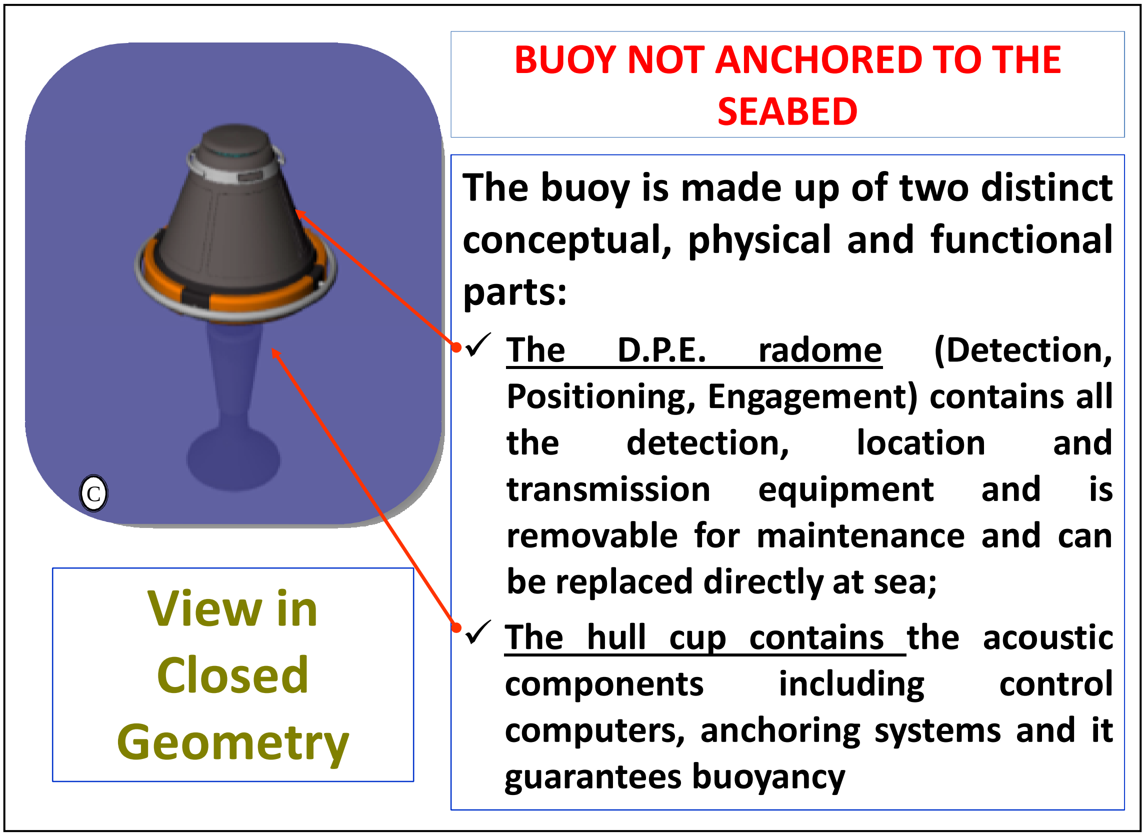

Figure 5: Image of the buoy not anchored in the “closed geometry”

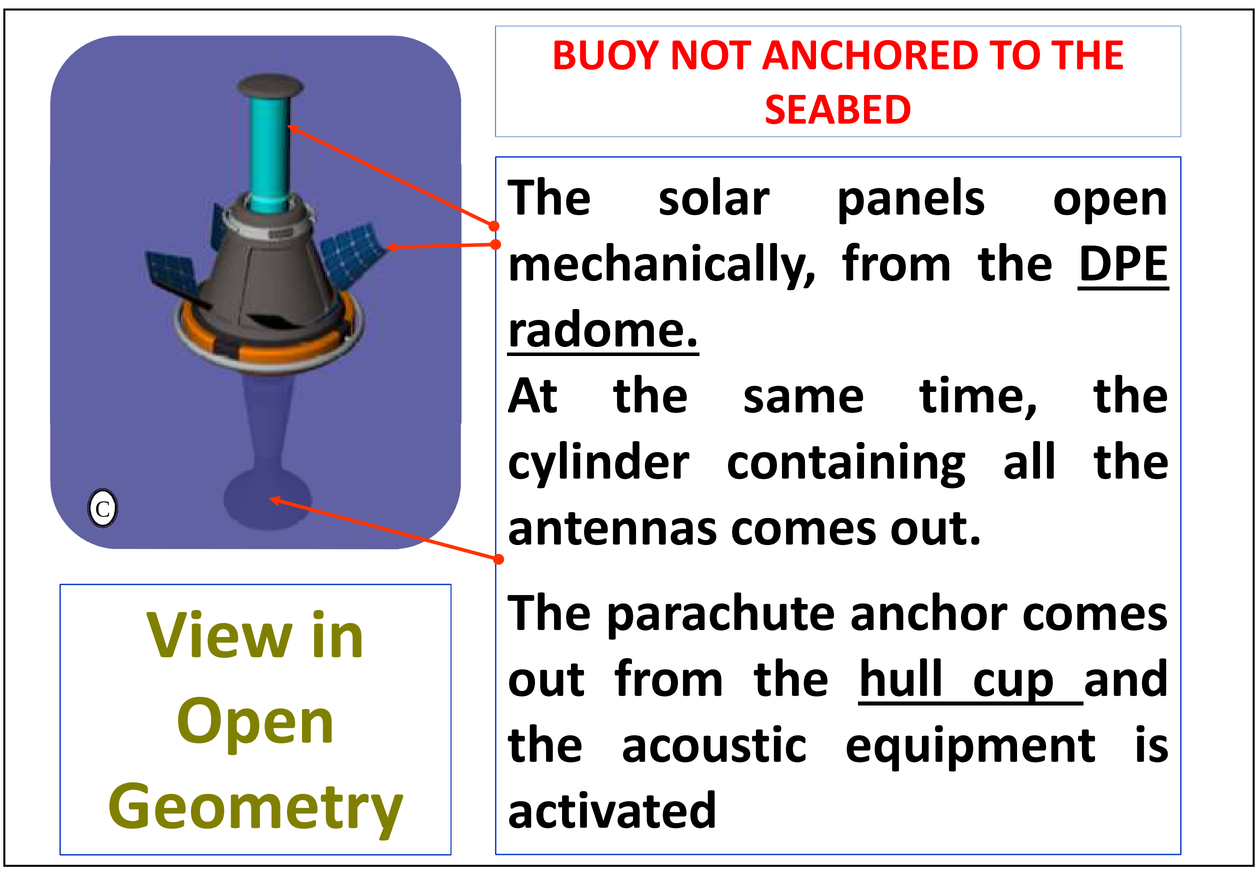

Figure 6: Image of the buoy not anchored in the "open geometry"

It will be necessary to provide for the construction of both the power supply system, based entirely on renewable energy (photovoltaic), and the communication system including its own positioning.

As regards the power supply system, this must be achieved by means of suitably placed solar cells which will act as a source of energy for the buoy by appropriately storing and managing the energy collected so as to allow the on-board systems to operate correctly and the communication system to receive and transfer the data operated by the sensors.

Conceptually, the buoy in question consists of two distinct functional, physical and conceptual parts: the radome D.P.E. and the hull cup (Figure 5).

The buoy has an open configuration in which the openings of the solar panels allow the satisfaction of the energy needs of the equipment on board (Figure 6).

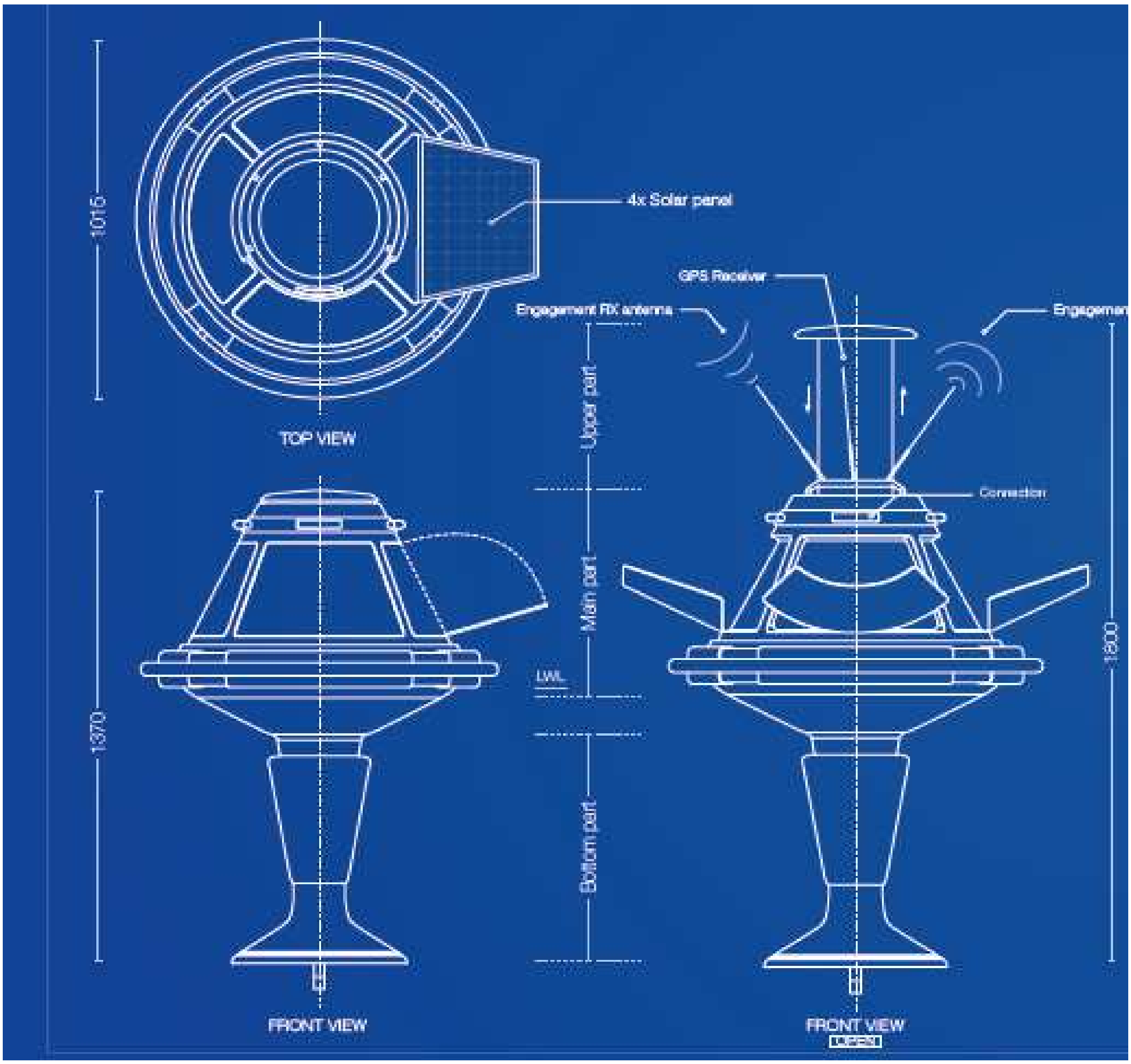

Figure 7: Dimensions of the buoy not anchored

The dimensions of the non-anchored buoy are enclosed in a cylinder with a radius of 1016 mm for a height of 1370 mm in the closed version and 1800 mm in the open version (Figure 7).

The anchored buoy, having the winch and the cable to "spin the anchor on the seabed, is enclosed in a cylinder of the same base but with a higher height.

In fact, the dimensions of the anchored buoy are enclosed in a cylinder with a radius of 1016 mm for a height of 1800 mm in the closed version and 2010 mm in the open version.

For the purposes of maritime control, they will operate on three physical surveillance volumes:

- The surface of the sea,
- The underlying water column
- The airspace above.

The Radome D.P.E. of both buoys contains the following equipment:

- A floating state with highly stable assets;
- An anchoring system in the sea that is not of a fixed type;
- A GPS locator
- An independent power supply system;
- A battery to store electricity;
- An independent transmission/reception system for continuous communication with the Command and Control Center or with a Digital Platform.
- A surveillance radar with remote/local activation/ deactivation device;
- An imaging device;
- A passive interception system of electromagnetic waves in the electromagnetic band with a local disabling device in case of power failure;
- A sonar that uses active acoustic energy;
- A hydrophone;
- A magnetic anomaly detector;
- A system that, for the surface target, integrates passive acoustic and active electromagnetic DPE information in order to have better maritime surveillance parameters.

Obviously the range of action of the aforementioned DPE triangle (Detection Positioning Engagement triangle) will differ for each of these three areas according to the limits of the sensors used and the physical characteristics of the three environments.

Last but not least, the "Engagemernt" function of the triangle D.P.E. allows the forwarding, in real time, of the data collected through communication devices embarked on the aforementioned platforms.

The communication system can be both of the satellite type and also of the VHF type and therefore capable of sending data to Command and Control Centers based on land and / or installed on ships and / or aircraft.

IV. The Characteristics of the "Radome D.P.E."

The current state of the art of technology, in the current availability of Italian companies such as those included in the Italian Group of High-Tech Manufactures, (IGHTM) business network, allows the previously listed equipment to be operated on the buoy.

These are put into operation when the buoy in the water assumes an "open configuration and becomes in fact operational.

Technically, the electromagnetic receiver, located in the emerged part of the buoy, is made up of antennas, a Radio Frequency Front-End and a broadband processor capable of identifying the electromagnetic scenario relating to the targets detected both underwater and on the surface.

The active and passive acoustic sensors are positioned below the waterline of the buoy and are able to provide information relating to both submerged and surface navigation targets.

Each "radome D.P.E. it contains a satellite positioning system (GPS) so that it can transmit its position during the operational phase ("Positioning" function of the triangle D.P.E.).

The functions that the electromagnetic receiver are able to transfer for each single detected emission: both that of the arrival direction and that of the parameters with which the emission is recognized on the basis of a programmable library that can also be updated through a system of "remote control".

The frequency band in which the receiver operates is between 2 and 18 GHz.

As mentioned, it must have an autonomous electricity production system that uses renewable solar sources and an electric storage battery.

The passive system of interception of electromagnetic waves consists of a digital goniometric receiver. It is an ultra-modern device of small dimensions, suitable for detecting electromagnetic emissions present in an extremely wide range of frequencies, as is of interest for digital electronic warfare receivers.

The Receiver, by means of its four antennas and the relative receiving channels, is able to measure the amplitudes and phases of the signals received by the antennas and to determine the direction of arrival of the various signals and also to detect all the characteristics of the electromagnetic emissions.

Important functions of the receiver are the detection of the characteristics of the detected radars such as

- Target Distance
- Direction of (Signal) Arrival
- Carrier Frequency
- Pulse Width
- Pulse Repetition Frequency
- Chirp Duration
- Chirp Delta Frequency
- Barker Code Number
- Analog Demodulation (for telecommunication)
- Digital Demodulation (for telecommunication)
- Detected Modulation Type (AM; FM; QAM; etc.)

This type of receiver, being able to operate in different modes, will be classified as a "Multifunctional Receiver". In particular, it can be set up to operate in the following operating modes:

- *"Wide Openmode"* – It consists of panoramic reception in the whole band from 100 MHz to 18 GHz. In this operating mode there is the maximum probability of interception for all emissions at all frequencies of the band.
- *"Channelized" mode* – It consists in channeling the entire band 100 MHz ÷ 18 GHz in sub- bands from 100 MHz to 1 GHz in order to explore one or more sub-bands with greater frequency and speed.
- *"Narrowband" mode* – It consists of tuning for a narrow frequency or sub-band inside the main band from 100 MHz to 18 GHz. In this operating mode, maximum receiver sensitivity and continuous signal demodulation are obtained.

The complete equipment consists of the following sub-assemblies:

Quadruple broadband antenna, RF Front-End, Digitization system, numerical processing Digital Data Output Circuit.

Specifically:

- *Quadruple Antenna* - is a group of broadband antennas of the "Plane spiral" or better Sinuous" type oriented to receive from the four cardinal points.
- *RF Front-End* - includes Low Noise Amplifiers for sensitivity, 0.1 to 18 GHz Band Filter, Fast Dynamics Translator.
- *Digitizing subsystem* - Provides for converting received analog signals into digital data.
- *Numerical Processing* - It consists of a digital circuit that includes a microprocessor, an FPGA, a fast memory, the firmware installed provides for the fast control of operations.
- *Data Display* - High resolution graphic display for viewing all data and for setting up appropriate actions.
- *Digital Data Output Circuit* - with its own BUS, it appropriately distributes the processed data.
- *Surveillance radar with remote/local activation/ deactivation device* consists of a modern and small-sized equipment, suitable for identifying other means of transport, such as boats of various types, airplanes, UAVs, etc. capable of carrying out surveillance of an area within a radius of about 40 kilometers.

The radar is capable of activating the following remotely controllable operating modes:

- *Short-distance surveillance mode* - which consists of an omnidirectional exploration with reduced emission power, minimum duration of the transmitted pulse, minimum quantity of pulses, to reduce the probability of being intercepted.
- *Wide-range Sighting Mode* - consists of identifying targets up to the maximum operating distance, determining their direction with good precision both in azimuth and in elevation.
- *Target Aiming and Tracking Modes* - to detect the position of the target and to follow its path. With this function the forecast of the future point of the moving target is carried out.
- *Multiple self-protection functions (ECCM)* - Monopulse mode, Frequency Jumping, Pulse Compression, Sidelobe Suppression, Velocity Gating, etc.
- *Cooperation with the ESM Receiver* - The Goniometric Receiver, equipped with great sensitivity, being always active (without Radio Frequency emission), can transfer the angular data to the Radar in order to refine the determination of the position of the target.

The complete equipment is physically composed of the following sub-assemblies: Active Antenna, Control Unit, Data Display, Digital Data Output Ports. Specifically:

Active Antenna - completely static and completely solid-state is formed by four faces arranged at 90°, each of which constitutes a rectangular array of relatively broadband radiators, capable of electronically scanning the beam.

The Transceiver modules (TxRx), directly coupled to the radiators, provide for

- Provide the power to be transmitted, necessary for correct operation in the desired range.
- Provide reception sensitivity and self-protection from any signals of strong intensity (reflections from large metal masses located a short distance from the antennas, beams from other radars operating nearby, etc.).
- Direct the antenna beam in space (in azimuth and elevation), both in transmission and reception, by appropriately varying the relative phase of each module.
- Taper the beam to optimize the secondary lobes.
- Cooperate for the ECCM.

The Control Unit: is a separate unit from the antenna, which also remotely controls all the Radar controls: Selection of the various Operating Modes (Short-distance Surveillance, Wide-range Sighting, Cooperation with ESM Receiver, Recognition signal emission (LIFF), ECCM Techniques It also provides for all numerical data processing and interfaces with the Active Antenna, with the Data Display and with the Digital Data Output Ports.

Data Display: High resolution graphic display for the visualization of all the transmitted data and for the predisposition of the appropriate actions.

Data Output Ports: for interface data to be provided or received from/for all peripherals.

It should be noted that the buoys mentioned in addition to being characterized by a relatively low cost, do not require periodic maintenance, during their life cycle, of the equipment on board and can be profitably placed at sea. It is understood that they can be recovered, replaced and rescheduled for future missions.

V. Wind Platform

The wind platforms to be dedicated to maritime surveillance are much larger than the buoys, so much so that they can have accommodation for staff, workshops for maintenance and storage of both buoys and other "hardware" dedicated to maritime surveillance.

Figures 8 and 9 show that the "D.P.E. radome" it is equivalent to that embarked on the buoys but the higher position gives the electronic equipment a greater geographical horizon. Furthermore, the generation of energy for operation is redundant, so much so that the excess of overproduction can be programmed to power other non-energy-producing offshore platforms or selected sites on land by means of cables laid on the bottom.

The wind platform, by virtue of its size (Figure 10) acts in all respects as a logistical base, illuminated in the EEZ (and therefore under the jurisdiction of the Coastal State), as well as a site aimed at maritime surveillance tout court.

Furthermore, depending on its structure, it can form a maritime agglomeration as shown in figure 11.

VI. Existing Commercial Platform

The commercial platforms are predominantly petroleum. An oil rig is an impressive structure used for the exploration of marine areas where potential hydrocarbon fields are located. When the existence of a field is identified and proven, the platforms are also used for drilling oil wells. Once the well is finished, the platform can be used to extract hydrocarbons from it, or it can be moved to another location to perform a new drilling.

As described above, the platforms can be essentially classified into two macro-categories:

- Drilling platforms
- Production platforms.

Both categories share the following facilities:

- Heliport, consisting of a platform dedicated to the landing of helicopters and often built in such a way as to be detached from the body of the plant for safety reasons but still properly connected to the body of the plant.

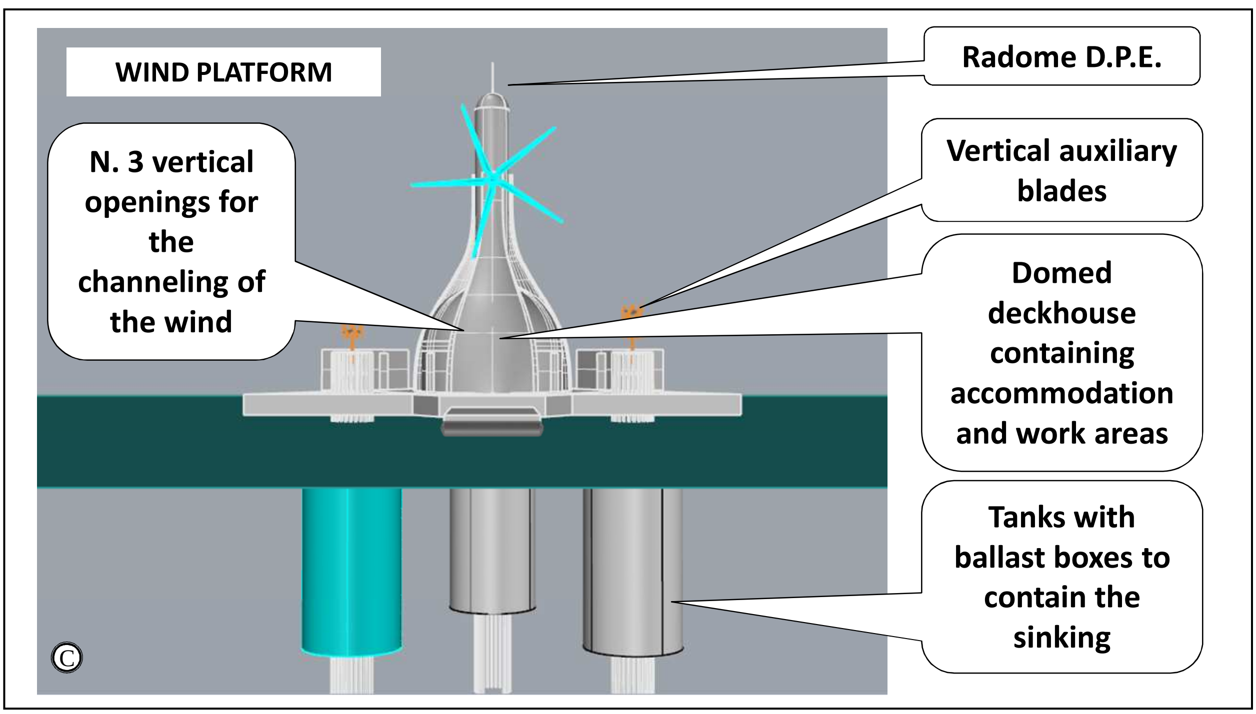

Figure 8: Artistic vision of the wind platform functional to maritime surveillance

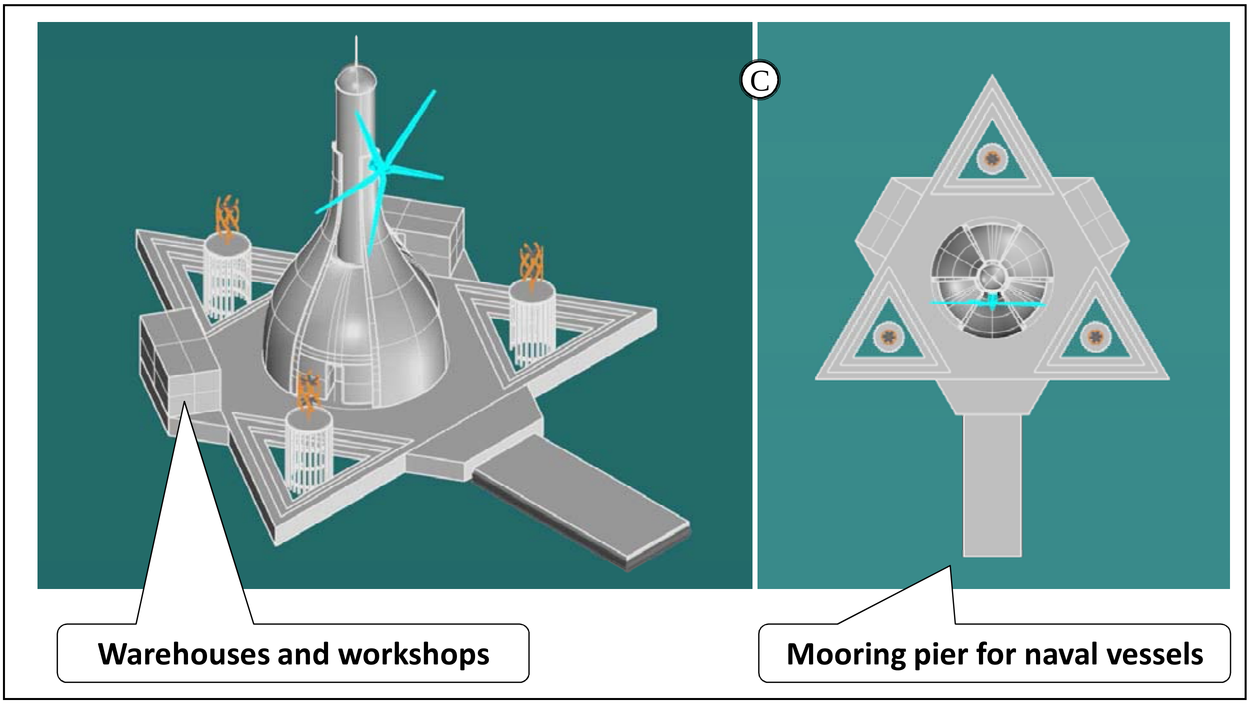

Figure 9: View of the wind platform where the docking capabilities of ships for refuelling or disembarking of personnel and warehouses/workshops are highlighted

- Equipped with special evacuation boats for personnel from the plant in case of emergency
- One or more cranes for loading on board and unloading materials from the support vessels to the platform
- Generating sets for the production of the necessary electricity
- Staff quarters, with canteen, kitchen and recreation room

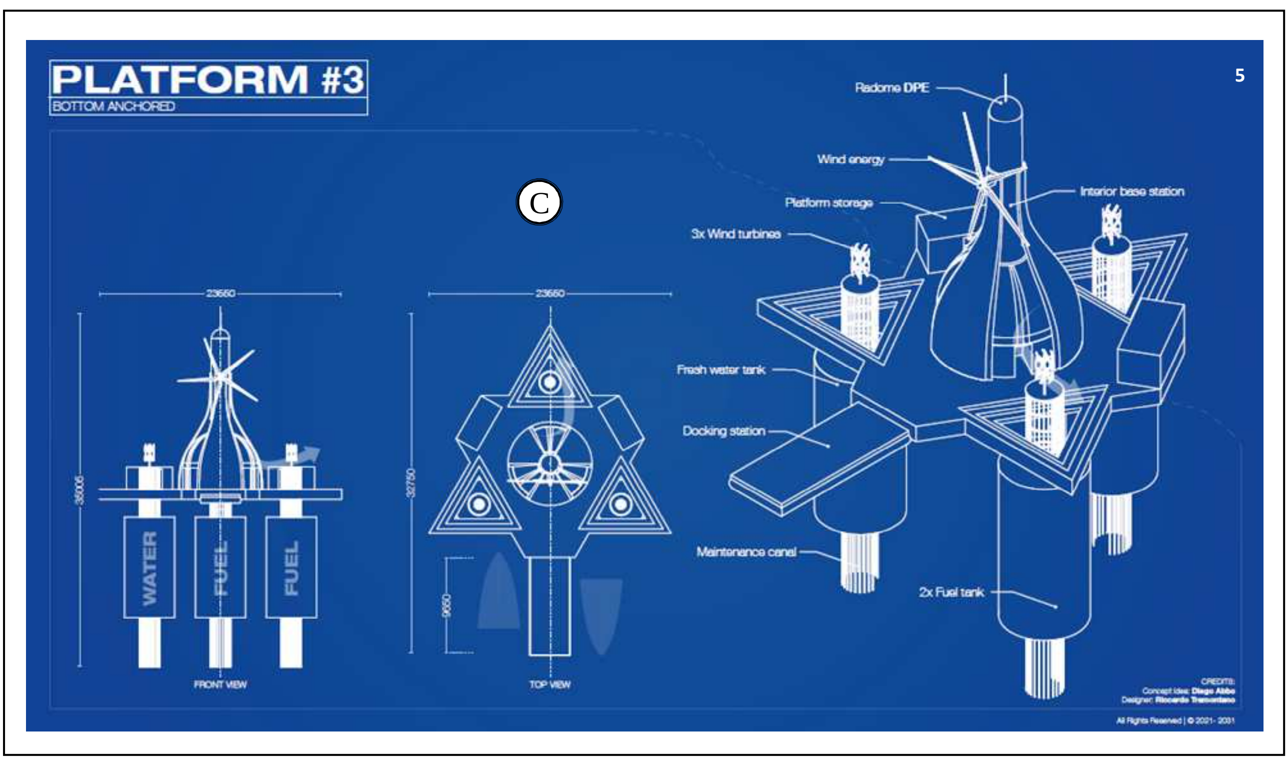

Figure 10: Dimensions of the wind platform

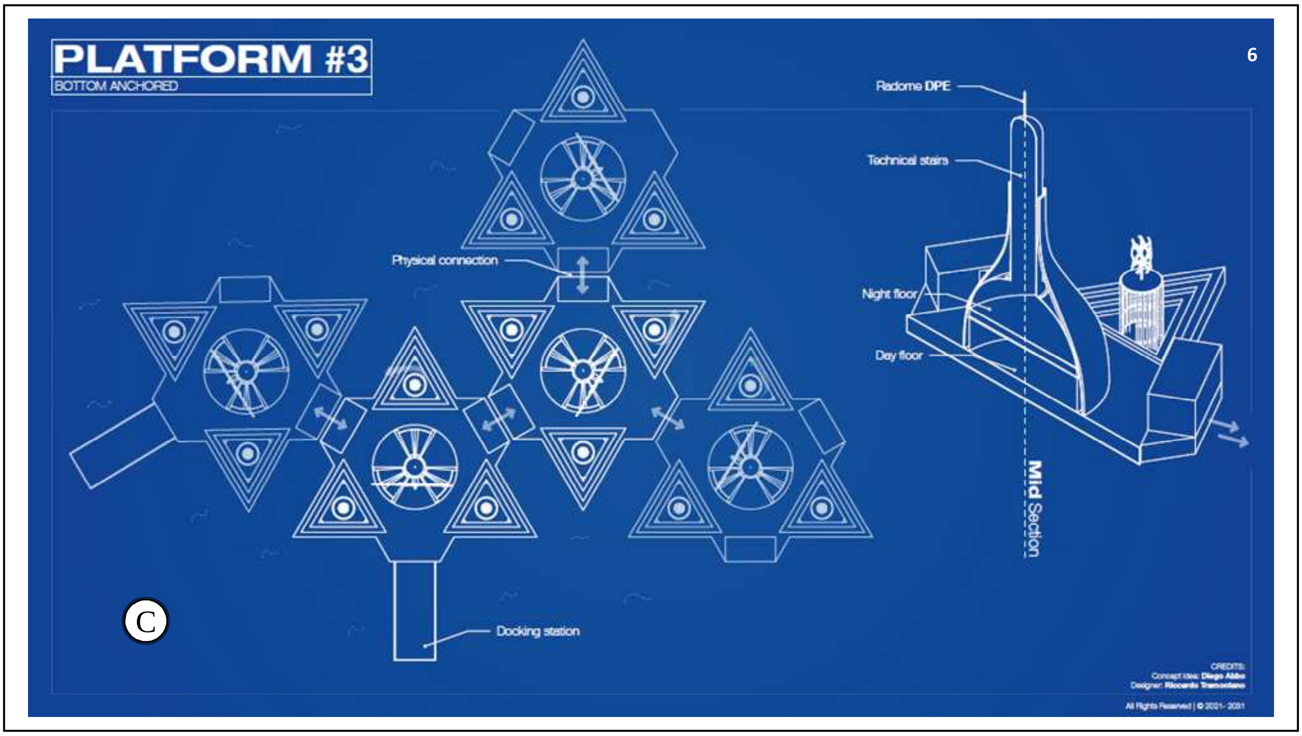

Figure 11: Agglomeration of wind platforms

- Drilling tower: always present in the drilling platforms, it can be absent in the production platforms if they are positioned in a field where the wells have been previously drilled or they can be removed if the development of the field has been completed and no other opportunities are foreseen of their use.
- Blowout preventer, usually abbreviated BOP, to prevent any eruptions of the well on which you are working.

The oil platforms are always manned while the platforms relating to offshore wind turbines can be manned or unmanned.

The sensors to be used would be the same ones mentioned above both for the wind turbines and for the buoys.

VII. Conclusions

The drafting of a maritime surveillance network using the platforms described from scratch or the implementation of the D.P.E. on already existing positions at sea it would increase exponentially the maritime surveillance capacity of any State and therefore of its Naval Power.

In fact, the aforementioned platforms represent, from a secondary use perspective, an effective operational support both with regard to the triangle D.P.E. (Detection, Positioning, Engagement) and with regard to the logistics supply in the area.

Furthermore, they would represent a "Dual use" backbone structure that can fulfill all the following tasks: surveillance for military and maritime police purposes, merchant traffic monitoring, a series of navigation aids and related dangerous situations, detection of flows of fish fauna, constant observation of environmental parameters of interest, measurement of the pollution rate.