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DESIGN ANALYSIS OF OFFSHORE ANTIPIRACY REAL-TIME FLOATING SURVEILLANCE UNIT (RFSU); A CASE STUDY OF THE GULF OF GUINEA

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ABSTRACT

This paper presents the design and analysis of a real-time floating surveillance unit (RFSU) in an attempt to proffer solution to the continuous challenge of sea-piracy in the Gulf of Guinea. Having highlighted the impacts of Piracy on the maritime industry in the region under review, and by examining the effectiveness of the current mitigating measures taken in operation, it was identified that these existing measures are expensive, and have severe limitations when combating Pirate attack towards a ship offshore. This novel design therefore is a combination of technologies such as the a Marine radar, Automatic identification system (AIS), Solar and Battery power system, VHF radio, moored-floating structure with signal transmission through the satellite communication system to the base station.

KEYWORDS: Anti-Piracy, Offshore, Real-time floating structures, surveillance Unit. Etc.

1. INTRODUCTION

1.1 Piracy in the Gulf of Guinea; an Overview

Sea-piracy has been a huge challenge in the Gulf of Guinea. The rise in the incidents of armed robbery at sea and piracy has continued to negatively affect the increase in seaborne trade in the Gulf of Guinea. These incidences can now only be compared to what happens in the Gulf of Aden (which comprises of Somalia, Yemen and the Arabian Sea).

In 2012 alone, there were about 58 attacks, including 10 hijacking. In 2013, the gulf experienced even more fierce piracy attacks. This trend lingered in 2014, but decline was noticed in 2015 and 2016 with some notable attacks in the first quarter of 2017. Most attack targets were vessels connected to offshore, oil and gas operations. However, other vessels trading in the region have also come under severe attacks. The direct financial costs of piracy, such as: ransoms, insurance premiums, the costs of re-routing to avoid piracy regions, deterrent security equipment & measures, naval forces, piracy prosecutions, and anti-piracy organizations are currently having huge impacted on seaborne trade (International Maritime Bureau, 2013).

1.2 Motivation for this study

Kidnap remains the most serious threat to mariners in the Gulf of Guinea, and further similar attacks will almost certainly occur in future. Therefore, there is no need to be complacent on the subject of sea piracy as the risk of kidnap and attacks on vessels operating in the region could resurface in greater dimensions if not tackled with modern research and knowledge. It requires therefore scientific means to combat sea-piracy in the Gulf of Guinea, hence the reason for designing a sustainable, real-time floating surveillance unit which will be anchored along the deep sea passages corridor of the gulf. This is the motivation for this research work.

1.3 Description of the Gulf of Guinea

The Gulf of Guinea is the North-Eastern most part of the tropical Atlantic Ocean between cape loges in Gabon, north and west to cape three points in Western region Ghana. The intersection of the Equator and prime Meridian (zero degrees latitude and longitude) is in the gulf. Among the many rivers that drain into the Gulf of Guinea are the Nigeria and the Volta.

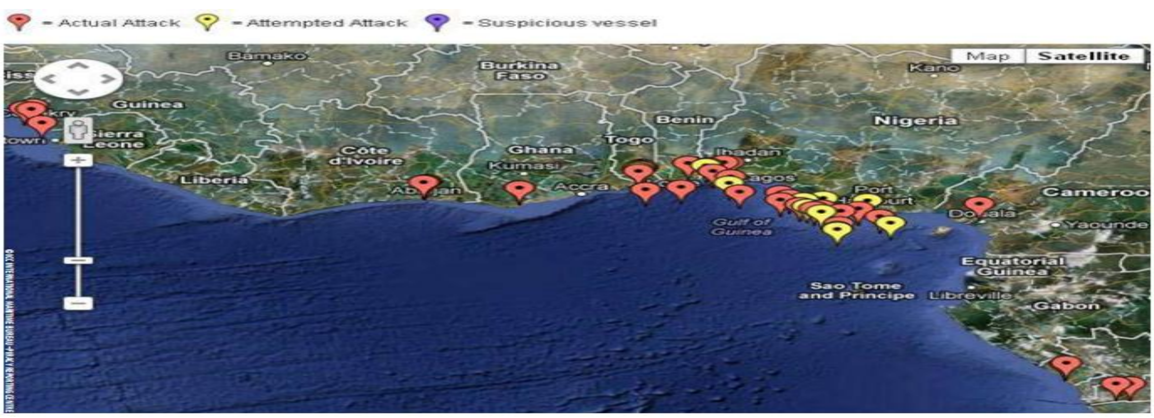

Figure 1: Aerial description of the pirates attack in the Gulf of Guinea (Source: (Ocean Beyond Piracy, 2016).

Coordinates; $1^0 0'N\ 4^0 0'E$

River Sources; Niger

Ocean/Sea sources; Atlantic Ocean

Basin Countries; Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Equatorial Guinea, Gabon, Säo Tomè and Principe, Congo Republic, DR Congo, Angola

Islands; Bioko, Säo Tomè, Principe, IIheu, Bom-Bom, IIhèu, Caroço, Elobey, Grande, Elobey Chico, Annobon, Corisco, Bobowasi.

1.4 Effects of Piracy on Seaborne Trade in the Gulf of Guinea

Economic Costs of Piracy and Robbery in the Gulf of Guinea

The international community, regional states, and the shipping industry incurred significant costs dedicated to deterring and combating piracy through capacity-building, naval operations, contracted security, and ship protection measures. From the breakdown below, it is estimated that $793.7million was the total costs related to piracy and armed robbery in the Gulf of Guinea in 2016 in terms of economic loss or costs. This amount is the least estimate between 2008-2015, and it could get worse if not scientifically handled.

Table 1: Approximate Total Economic Cost of Piracy in 2016 (Source: (Ocean Beyond Piracy, 2016).

Items	Amount In Millions of Dollars
Cost of Insurance	42
Cost of Labour	114
Cost of Stolen Goods	0.6
Cost of Related deterring Piracy	636.1
Total	$793.7Million

2. Current Anti-Piracy Measures In the Gulf Of Guinea

Over the years, incidents of sea piracy have increased mostly due to the fact that the Sea-pirates have become familiar with equipments used in fighting them and as a result they (the Sea-pirates) supposedly device means of scaling existing counter measures. Continued successful attacks by these sea-pirates in the gulf are an indication that these counter measures have over time become ineffective (Defence web, 2016). The approaches currently used to counter the activities of the sea-pirates in the Gulf of Guinea are.

2.1 The Secure Ship Approach

Secure ship refers to the ability of a vessel to own its means of frustrating external attacks when it is passing through danger zone. However, proper security plan is needed onboard in other for the ship to accomplish this self-saving task. Therefore, three zones of protection with necessary equipment are worked out after considering individual configurations. It has the first, second and third protective zones. (Cristina, 2013).

2.2 Protective Equipment Measures

The equipment that are currently been used in fighting sea-piracy in the gulf include, fire hoses, electrical fences, long range sound canon, propeller arresting traps, remote controlled patrol boat, dazzle guns, active denial system. These are not generally effective when the pirates' boarding craft approaches the target vessel with machine guns. In addition, most of the equipment are expensive and also needs a proper training for those who are going to use it (IODM, 2017), (Hobby Tron, 2017) & (GCaptainStaff, 2008).

2.3 Hired Escorts and Security Vessels Approach

Efforts to secure the area (Gulf of Guinea) from pirates using hired security boats have for some time been in progress through the naval forces of the nations linked together by Atlantic Ocean. However, the safety in the area provided by the naval forces has not been enough to avert all pirate actions and attacks (Defense Update, 2017).

3. MATERIALS AND METHODS

3.1 The Real-Time Floating Surveillance Unit (RFSU)

The Real-time Floating Surveillance Unit (RFSU) concept consists of a floating structure that can be anchored in strategic locations in the gulf of Guinea and equipped with Radar and Auto Identification System in order to scan the surrounding area. The data recorded by the Radar and the AIS will be transmitted live, through a satellite antenna to a control station. The data from all the RFSUs when processed will be applied to keep a constant surveillance over the gulf. The power required for the operation of the Radar will be supplied by Solar panels, installed on the RFSU, through batteries to support the operation all the time.

3.2 The RFSU Components Analysis

3.2.1 Radar

The Radar will be a major part of the RFSU. Its main function is to scan the areas under surveillance. The Radar is operated with the principle of electromagnetic waves which is emitted from a transmitter via an antenna. These waves are reflected on any object that comes into contact. The reflected wave return to the antenna and are picked up by the radar receiver. From there, they are amplified and the distance of the object is calculated based on the time interval between the transmission and the receipt of the signal.

Target Range and height of Radar, Radar Type and Specifications

Typically, marine radars have an average of about 96 nautical miles. This can be affected by factors such as environmental conditions (i.e humidity, rain, cloud) inhibiting its range of effectiveness. Also, factors such as curvature of earth could affect the detecting range.

A thorough review was conducted and the JMA-5300MK2 series manufactured by JRC (Japan Radio Co) has been chosen to have the desired characteristics for the application required by this design. Specifically the JMA-5322-6HS model is the radar on which the calculations are based on. The specifications of the Radar are attached in the appendix. The main characteristics are presented in the following table.

Table 2: JMA-5322-6HS Specifications (JRC 2008, 2008).

Model	**JMA-5322-6HS**
Range scale	0.125/0.25/0.5/0.75/1.5/3/6/12/24/48/96 NM
Antenna length	6ft
Transmitting power	25kW
Transmitting frequency	9410mHz ± 30mHz
Beam width 3db	Hor. 1.2°, Ver. 20°
Power supply (voltage)	DC 21.6 - 31.2V
Power consumption (at max wind load)	700W
AIS interface unit	NQA-2103 built-in NDC-1417

3.2.2 Automatic Identification System (AIS)

The Automatic Identification System is a vessel tracking system that is used in order to communicate navigational data concerning a vessel. The AIS system can be compared to the Air Traffic Control system applied on marine traffic. AIS transmit data every few seconds over two dedicated VHF marine frequencies (The Coastal Passage, 2012). The data transmitted should include: Ships Name, Call Sign, Ships Type, IMO Number, Position, Course, Speed, Rate of Turn and other safety related information (International Maritime Organisation, 2016).

International Maritime Organization in the year 2000 adopted a new requirement under Regulation 19 of Chapter V of SOLAS for all ships being equipped with AIS to provide information about the ship to other ships and to coastal authorities. The requirement applies on ships of 300 gross tonnage and upwards engaged on international routes, on ships of 500 gross tonnage and upwards not engaged on international routes and on all passenger ships regardless their size. This requirement became effective for all ships by 31 December 2004 (International Maritime Organisation, 2016).

AIS data can be combined by modern radars in order to provide an integrated configuration of the targets identified by the Radar and the vessels recognized by AIS and to be projected over electronic charts (ECDIS) to provide better and more reliable information concerning the vessels navigating in the area. Any vessels not equipped with AIS are identified by the Radar and can be distinguished from others.

3.2.3 Solar Panels

Solar panels convert into electrical power energy emitted by the sun in the form of solar radiation. The average solar radiation energy reaching the surface of the earth is 1000 Watt/m2. Modern solar panels convert this energy to electricity with efficiency reaching up to 17% with STC Power rating per unit of area of 190.03W/m^{2}as can be seen in the following table. However, due to losses in the system, modern solar panels can only convert this energy to electricity with efficiency between 10 to 15% resulting to an average power production of 100 to 150 Watt/m2.

Table 3: Efficiency of Solar Panels.

Manufacturer	ID	STC	Density	Eff.	Tier
Sanyo Electric	HIP-200BA19	200	14.89	17.24%	1
SunPower	SPR-200-WHT-U	200	13.55	16.08%	1
Canadian Solar	CS5A-200M	200	13.29	15.66%	1
Suntech Power	PLUTO200-Ada	200	13.28	15.66%	1
Trina Solar	TSM-200DA01A	200	13.12	15.64%	1
Kyocera Solar	KC200GT	200	12.03	14.74%	2
Schuco USA	SPV 200 SMAU-1	200	11.82	14.21%	3
BP Solar	SX3200B	200	11.52	14.17%	3
Yingli Green Energy	YL200P-26b	200	11.26	13.65%	4
ET Solar Industry	ET-P654200	200	11.18	13.61%	4
Evergreen Solar	ES-200-RL	200	10.69	13.40%	4
Sharp	ND-200U1	200	9.86	12.27%	5

Source: (Daily Tech, 2016)

After series of analysis, the Sanyo Electrical product with model number HIT-N240SE10 was recommended to be most suitable after series of research on different solar panels sampled.

Note, this is only specifically analyzed for this design application not on general characteristics. The specification sheet of the solar panel is attached as appendix.

3.2.4 Power Storage Device (Batteries)

The RFSU will make use of power storage devices like the batteries for conservation of energy.

The power that can be stored in a battery is expressed in Ampere-Hours (Ah) this indicates for how many hours a battery can produce energy at a given current (i.e. a battery rated at "100 Ah @ C20" means that is able to support for 20 hours a load at 5 Amperes, 20h * 5A = 100 Ah). Long life deep cycle batteries are manufactured in 2 Volt cells that can be connected in series in order to provide the required output voltage (EDC, 2011).

After a research in available batteries for solar panels the "OPzS SOLAR 1650" model of "EXIDE CLASSIC SOLAR BATTERIES" with nominal cell voltage of 2Volt and a capacity of 1440Ah @ C48 was selected as the most suitable for application on this design. The specification sheet of the battery is attached as appendix.

3.2.5 Anchoring of the FSU

The area in which each unit will be positioned will be studied to choose a suitable anchoring system for the RFSU. The Units are to be anchored along the length of the IRTC in order to provide a constant monitoring of the area. Considering the depth of water in the Gulf of Guinea varying at different areas, after examining a navigation map of the area range from 1,800 to 3,000 meters, and for the purpose of this research, a maximum depth of 3,000metres will be used for the calculations.

The Suction-Embedded Plate Anchor (SEPLA) Anchoring device which has been severally used in the Gulf of Guinea will be adapted for this design. The functional requirement of SEPLA is to resist the specified maximum factored mooring line load, while avoiding significant displacements, both in the direction of the applied load or vertically. SEPLA holding capacity is related primarily to three basic aspects, which must be defined for the design of the solution, those aspects are: Anchor plate area, un-drained shear strength, Penetration depth (Wang & Et.al, 2013).

The advantages of the SEPLA Anchoring systems include the following: Cost of anchor element is the lowest of all the deep-water anchors. It uses proven suction with the caisson installation methods. It also provides an accurate measure of embedment and position of the anchor. Design based on well-developed procedures for plate anchors. Experience in the Gulf of Guinea (Wang & Et.al, 2013).

4. RESULTS AND DISCUSSIONS

4.1 Power Evaluations of the RFSU

4.1.1Power Required by the Radar

The power required for the Radar operation is given from the manufacturer in the specification sheet. The power consumption, per hour, of the radar at maximum load is 700 Watt and the power supply required is DC 21.6 -31.2 Volts.

Using the formula of Power in electrical circuits, and assuming an average power supply at a voltage of 24 Volts

$$P = V*I \rightarrow I = \frac{P}{V}$$

$$I = \frac{700W}{24V} = 29.17 Ampere$$

Hence, a Power supply that can provide about 29.17 Amperes of current at a Voltage of 24 Volts is needed.

At maximum load, the total Power required for 24hours operation by the Radar is thus;

$$700\frac{W}{h} * 24h = 16800 Watts\ (per\ day)$$

4.1.2 Solar Panel Power Generation Capacity

The solar panel selected for the installation will produce about 190Watt/m2 at the rated efficiency in table (3). The standard dimensions of the panel are 1.980m height and 0.798m width. From the electrical characteristics stated in the specification sheet provided by the manufacturer it is stated that at Nominal Operating Cell Temperature (NOCT) the Power production of the panel is 182 Watt while in low irradiance conditions the power output is 45.9 Watt. At a worse condition, assuming an average power production of 100 Watt per hour, and average hours of Sunlight at 6 hours/day a solar panel can produce:

$$100\, {}^{W}/_{h} * 6\, {}^{h}/_{day} = 600\, {}^{W}/_{day}$$

But the radar require at-least 16800W per day, so $\frac{16{,}800\ W\ per\ day}{600\ W\ per\ day} = 28\ solar\ panels$

For safety of operations and tolerance, 15% contingency for the number of solar panel needed should be added making it (28+4.2) = 32.2

Therefore, considering 32 solar panels for the power generation

$$600\,{}^{W}/_{day} * 32 = 19200W/day$$

Hence, 32 solar panels are capable to provide the power required for the radar operation.

4.1.3 Power Storage Device (Batteries)

This design will make use of an already available battery technology. The power produced by the solar panels has to be stored in to batteries in order to be supplied to the Radar for 24 hours of operation. The battery though must not be completely discharged therefore a 50% depth of discharge will be considered. The requirement from the battery is to supply at 24 Volts, 29.16 Amperes current for 24 hours. Therefore the required capacity in Ampere-hours (Ah) can be calculated as following

$$(Current) * (Time\ in\ hours) = Battery\ Capacity$$

$$29.17A * 24h = 700.08Ah$$

$$\frac{700.08Ah}{0.5} = 1400.16Ah$$

From the above calculation, the battery with discharge characteristics of 1140Ah @ C48 will be suitable for application on the design. By implication, this is a battery with a capacity to provide 48 hours 30 Amperes of power. The required voltage can be achieved by connecting in series 12 battery cells of 2 Volts each.

4.2 Structural Analysis of the Real-Time Floating Surveillance Unit (RFSU)

The structural outline of the Real-time Floating Surveillance Unit is designed as a standalone structure to be located offshore the Gulf of Guinea. The RFSU consists of the steel structures, the solar panels, the radar, and VHF-radio and satellite communication system. Figure (6) is the plan showing the overall structural design and outline of the RFSU.

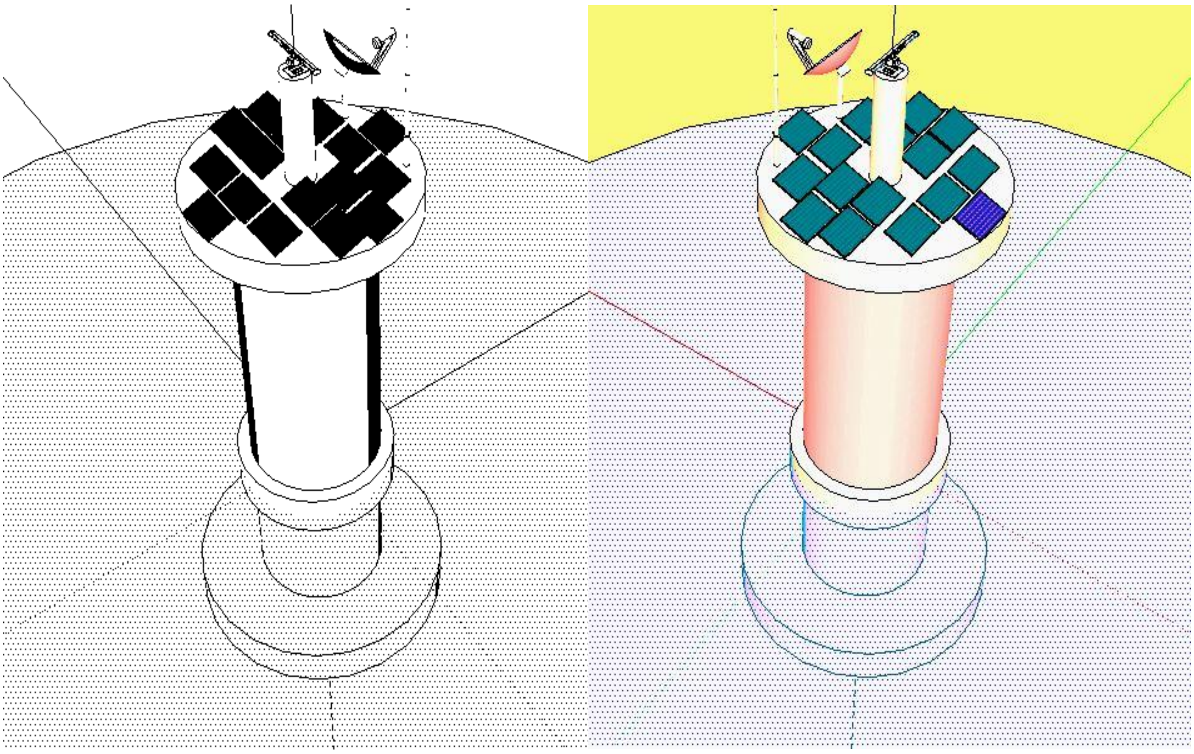

Figure 2: General Structural Layout of the RFSU System.

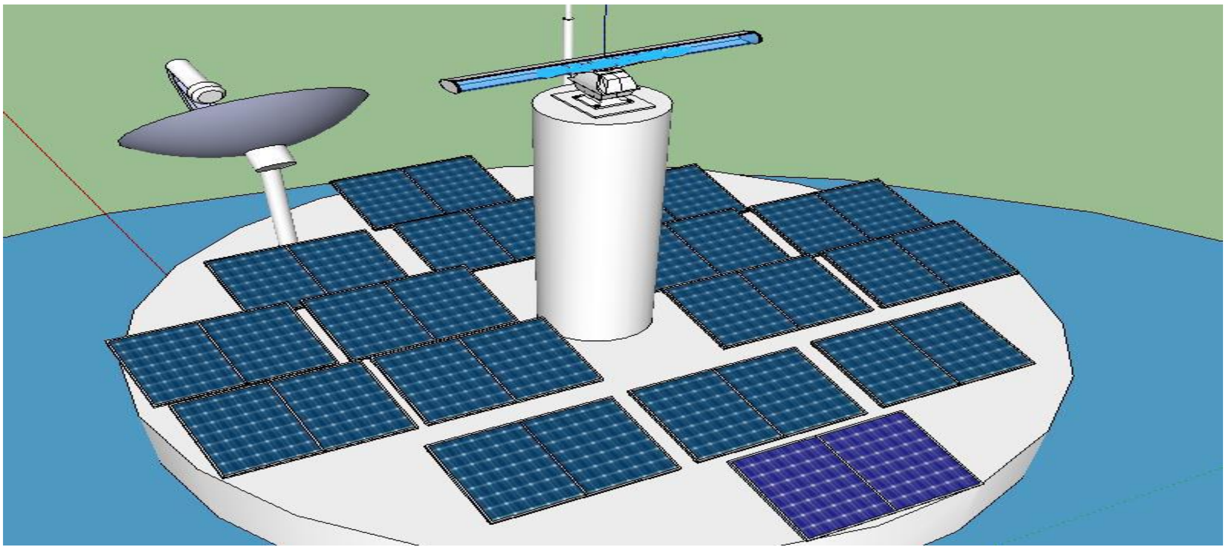

Figure 3: The RSFU and Equipment mounted on the Top.

The dimensions of the RFSU are at this stage only preliminary design. The main body of the RFSU is consisted from a tubular hollow pillar with 4m diameter and 16m height. The pillar connects a floating tank with a platform where the Solar panels, the Radar, the VHF antenna for the operation of the AIS and the signal transmitting Antenna are installed. The floating tank has a diameter of 10m and height 2m, and the platform diameter 8m and height 1m. The following figure illustrates the dimensions of the RFSU.

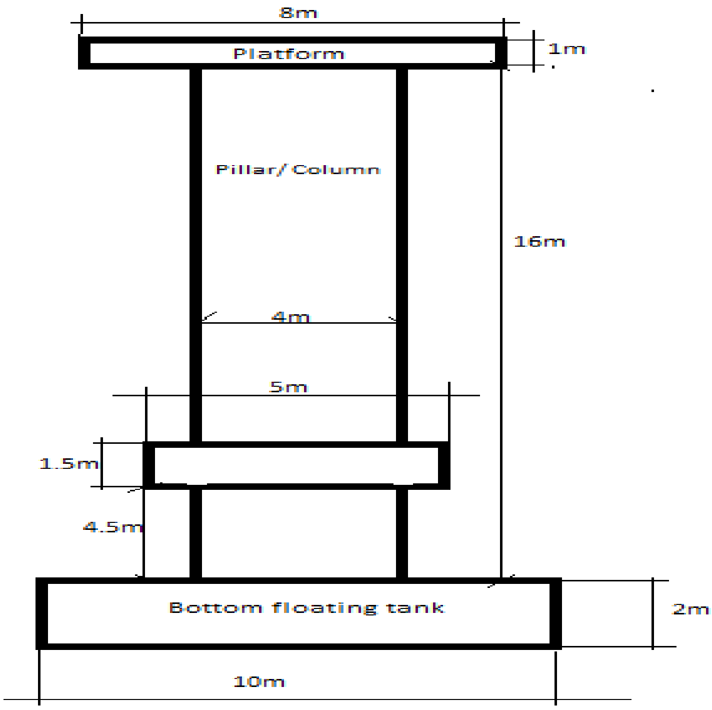

Figure 4: RFSU General Sketch and Dimensions.

In the above figure a collar positioned on the pillar 4.5m above the connecting point with the Floating Tank can be seen. This collar is used to increase the Water Plane Area of the construction, hence improve the stability.

4.3 Weight and Displacement Evaluation of the RFSU

Weight Evaluation

The weight of the FSU can be divided in two groups: (1) the weight of the structure and (2) the weight of the equipment and mooring rope.

4.3.1 Weight of the Structure

In order to calculate the weight of the structure some assumptions were made:

- The structure will be constructed by marine grade steel using 25mm thickness steel plate supported by frames as would require from a structural integrity point of view.
- The weight of the additional frames and supports of the structure will be assumed to be a fraction of the weight of the shell plates. For the purposes of the calculations it will be assumed that the weight of the shell plates will be increased by 50%.
- The weight will be calculated by multiplying the volume of steel used, to the density of steel ρ=7850 kg/m3=7.85 ton/m3 (Engineering Toolbox, 2012).

The volume of the shell plates is calculated considering 25mm thickness, based on the dimensions of the structure according to the following formula.

$$Vcylinder = \pi * R^2 * h$$

Where h is the height and R is the radius of the cylinder.

Volume of steel for floating tank;

$$V_{steel}\ for\ floatingtank = [\pi * (5^2 - (5 - 0.025)^2) * 2] + 2 * (\pi * 5^2 * 0.025)$$

$$V_{Steel\ for\ floating\ tank} = 5.49m^3$$

Volume of steel for Pillar;

$$V_{steel\ for\ pillar} = \pi * (2^2 - (2 - 0.025)^2) * 16$$

$$V_{steel\ for\ pillar} = 5m^3$$

Volume of steel for platform;

$$V_{steel\ for\ platform} = [\pi * (4^2 - (4 - 0.025)^2 * 1] + ((\pi * 4^2 * 0.025) * 2)$$

$$V_{steel\ for\ Platform} = 3.14m^3$$

Volume of steel for Collar;

$$V_{steel\ for\ colar} = [\pi * (2.5^2 - (2.5 - 0.025)^2) * 1.5] + [2 * (\pi * (2.5^2 - 2^2) * 0.025]$$

$$V_{steel\ for\ colar} = 0.94m^3$$

Therefore, the Total volume of steel shell plate;

$$V_{steel} = ((5.49 + 5 + 3.14 + 0.94) + 0.5 * (5.49 + 5 + 3.14 + 0.94))$$

$$V_{steel} = 21.85m^3$$

The weight of the structure is thus calculated;

$$W_{structure} = V_{steel} * Density$$

$$W = V * \rho$$

$$\boldsymbol{W_{structure} = 21.85 * 7.85 = 171.52\ Tons}$$

4.3.2 Weight of equipment and mooring rope

The weight calculation of the equipment will be calculated by the data provided by the manufacturers in the specifications attached to the appendix. The weight of the Radar and electronic equipment will be considered negligible.

Weight of solar panels, as calculated previously 32 solar panels will be used for the power requirements of the RFSU. The weight is provided by the manufacturer is 15 kg per solar panel, therefore;

$$W_{solar\ panels} = 32 * 15 = 480kg = 0.48Tons$$

Weight of batteries, as stated previously 12 battery cells will be used for the requirements of the circuit. The weight is provided by the manufacturer as 73.2 kg per cell, therefore;

$$W_{batteries} = 12 * 73.2 = 878.4\ Kg = 0.878Tons$$

Weight of mooring rope, as stated previously the depth of the area in which the RFSU's are going to be anchored varies, therefore the calculation of the mooring rope will be performed assuming an average depth of 3000m using the largest rope of the GAMA 98 series where the weight in water is provided by the manufacturer as 15kg/m, therefore;

$$W_{mooring\ rope} = 3000 * 15.2 = 45600Kg = 45.6Tons$$

Therefore;

$$W_{equipment} = 0.48 + 0.878 + 45.6 = 49.968Tons$$

Therefore the Total Weight of the RFSU

$$W_{RFSU} = W_{structure} + W_{equipment}$$

$$W_{RFSU} = 171.52 + 49.968 = 218.478Tons$$

4.4 Displacement Evaluation

The Principle of Archimedes, "states that a body completely or partially submerged in a fluid at rest, will be acted upon by an upward or buoyant force, the magnitude of which is equal to the weight of the fluid displaced".

Hence, the weight of the structure must be equal to the buoyancy force in order to float. The buoyancy force is equal to the weight of the displaced water. Therefore the weight of the displaced water by the FSU must be equal to the total weight.

$$W_{Displaced\ water} = W_{RFSU}$$

Therefore;

$$W_{RFSU} = V_{Displaced\ water} * \rho_{Sea\ water}$$

$$V_{Displaced\ water} = \frac{W_{RFSU}}{\rho_{Sea\ water}} = \frac{218.478}{1.025} = \mathbf{213.15m^3}$$

The volume of the submerged part of the RFSU therefore must be at least 213.15m^3 in order to float. This volume is the summation of the volume of the float tank and the part of the pillar under the collar. Therefore

$$V_{float\,tank} = \pi * R^2 * h = \pi * 5^2 * 2 = 157m^3$$

$$V_{pillar} = \pi * R^2 * h = \pi * 2^2 * 4.5 = 56.5m^3$$

$$V_{submerged} = 157 + 56.5 = 213.5m^3 > 213.15m^3$$

From the evaluation, it can be seen that the volume of the floating tank and the lower part of the pillar can provide the required displacement to float the RFSU. The final displacement of the RFSU can be adjusted using solid ballast blocks in the float tank.

4.5 Positioning and Operation of the RFSU

The figure below shows the RSFU positioned at strategic locations in the Gulf of Guinea. The distance from Accra (4°32’46.89” N, 0° 32’53”.69” E) to Lome (5° 32’34.91”N, 2° 01’53.69” E) is approximately 107.4 nautical miles. Then from Lome through the Bight of Bonny (3° 34’41.29”N, 7° 16’04.42” E) down to Malabo (2° 22’08.38”N, 9°35’13.46” E) is approximately 498.9 nautical miles. Again, from Malabo to Equatorial Guinea (1° 12’28.24”N, 9° 05’27.56” E) coast is also approximately 85.5 nautical miles. In summation, the distance in the Gulf of Guinea that will be covered by the RSFU is approximately 691.8 nautical miles.

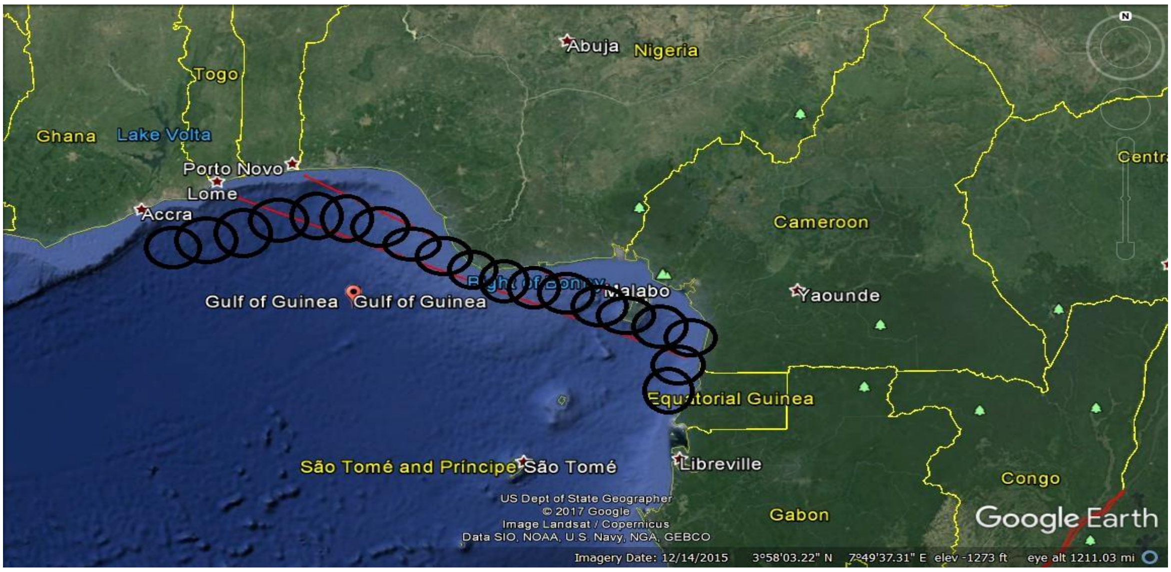

Figure 5: Plots showing expected positioning of the RFSU in the Gulf of Guinea.

As can be seen, the area between two consecutive RFSU is simultaneously monitored by two units. In the event that one particular unit malfunctions, the area will still be covered by the two other units.

At the total distance of 691.8 nm, and interval of about 27 miles from each unit, it will therefore take about 26 RSFUs to cover the proposed area for constant 24hours real-time monitoring. The additional 12 RSFUs will be positioned at the middle of each unit for redundancy. This brings it to total of 38 RSFUs for the area under consideration at the Gulf of Guinean.

This concept is typically based on the condition that all vessels navigating the area will be obligatorily required to install AIS in order to be identified by the system. Any vessel without AIS is marked as a threat unless otherwise stated. As usual, the radar will scan the area and identify vessels sailing in the area through the AIS. Any target scanned by the radar and data of such a vessel is not provided through the AIS, and then it will be regarded as a threat. Then the operator in the shore station will be able to notify ships sailing in the area not to approach the area and the patrolling naval vessels to proceed towards the area in order to identify the target.

CONCLUSION

This study is based on the supposition that an offshore floating structure is designed and equipped with marine radar, AIS interface. The system is to be powered through a battery array from solar panels and transmit its signal through a satellite antenna to a control station otherwise referred as the base station. The signal that will be generated will be real-time. The data used for the RFSU design was sourced and only considered for the case study which is the Gulf of Guinea. From the analysis, the deployment of the sophisticated systems such as the RFSU will greatly decimate the operations of the sea-pirate in the oil-rich gulf. The Researchers recommends that the engineering design and structural integrity of the floating structure be further ascertained before venturing into fabrication and construction and also the required equipment for the signal transmission system as well as the required ancillary equipment for the operation of such a unit as the RFSU be further considered at the advanced stage.

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