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A Novel Wave Bird Concept for Marine Surveillance

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Abstract

The use of a conventional Wave glider for surveillance application is less explored due to the limitation in speed and low perspective vision due to its low profile. This paper proposes the design of a wave powered vehicle for fast surveillance in sea waters with real time communication with shore.

Keywords: Global Positioning System (GPS), Helium Chamber, Linear Generator, Radar, Wave Bird

1. Introduction

When a wave glider is used for surveillance application the main purpose is to get the data faster and precise position of the glider for accurate data acquisition. some of the potential oceano-graphic applications will require precise positioning and navigation beyond the wave glider platforms current capabilities in the potential for precise localization of a wave glider based on a augmenting the onboard instrumentation (adding a high quality global positioning receiver and inertial measure. unit) and implementing an estimation algorithm (an extended Kalman filter using a two-body dynamic model has been discussed. The mechanical wave gliding phenomenon developed posses several draw backs such as increased time for data gathering and inability to be used as surveillance equipment. The existing design of wave glider design is as shown in Figure 1.

Here the propulsion of the Glider is passive and mechanical, it converts energy from wave motion into thrust. This propulsion system exploits the natural difference in wave motion between the surface float and the submerged glider. Articulating fins or wings, attached to the sub converts wave energy to generate more than 1.3kN of thrust as they pivot vertically. The vehicle produces forward thrust independent of wave direction as its float moves up and down with each wave and the sub-sea glider part tows the float forward.

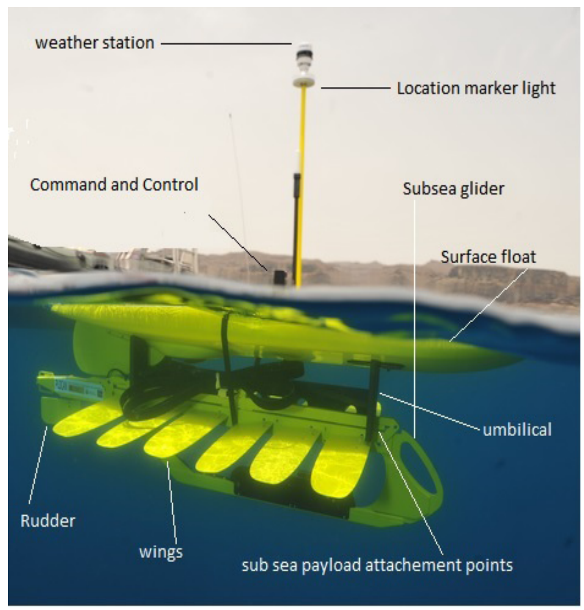

Figure 1. Exisiting Wave Glider.

The forward speed of the glider is dependent on the overall buoyancy force provided by the surface float when it is tethered to the subsea glider. The vehicles mass and buoyancy varies with payload, so the surface float, umbilical and subsea glider must be balanced and tuned to provide optimal propulsion performance. As the vehicles mass and buoyancy vary with payload, the speed of the glider is limited, which can be considered as a major drawback. Hence the system is not capable for immediate surveillance.

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2. Proposed Design

Here we propose the design and development of a highly reliable fast wave bird which can fly as well as swim in shallow waters. The top view and topological layout of components are shown in Figure 2 and Figure 3. The power system is charged up by reciprocating type linear power generators and also light weight thrusters attached along the WB's bottom side. The thrusters will be used as a charger for normal conditions. When the fast movement is required the WB can use these thruster blades for propulsion application also in water and in air.

Helium gas is kept in a compressed chamber and when under an emergency conditions it can be released to the WB's peripheral chamber and let the whole system be lifted up to a small height. Helium gas is used to lift up the WB to a small height. Helium gas is selected for WB considering four main points as noted below.

An airship must lift four distinct categories of items.

1. Structure: Inherent weight of the airship itself, including structural elements of all kinds, engines, and solar panels if present (structure gas).
2. Payload: Cargo and passengers. This is the income source. In routine flight, payload, like structure fixed, so for lift purposes I will count it as part of structure gas.
3. Ballast: Buoyancy control. Airships drop ballast to increase buoyancy, and release "ballast gas" to reduce buoyancy.
4. Consumables, especially fuel: Consumption of lifting gas to offset the weight of fuel consumed during flight. "Fuel gas" is a category within ballast gas, with a few additional constraints.

3. Overview of Wave Bird

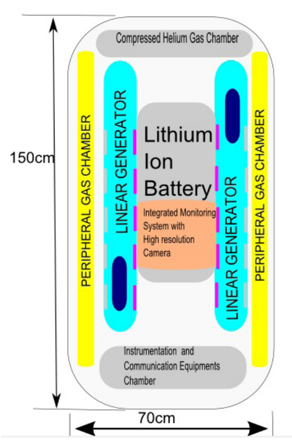

Figure 2. Wave Bird Top View.

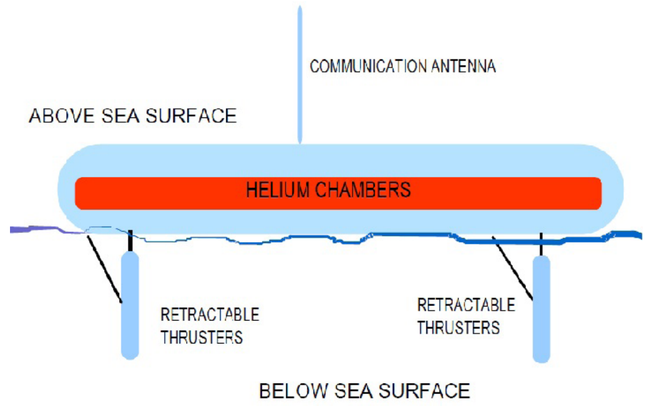

Figure 3. Wave Bird Side View.

4. Power Source for Wave Bird

The power needed for propulsion of WB is collected using three methods.
1) Linear Generator 2) Solar film sticker 3) Thruster working as generator.

4.1 Linear Generator

Linear generator uses the wave motion and the height of the waves to generate power, the theory of wave energy[3]. For propagating harmonic wave on deep water, half of the energy in the wave is potential energy and the other half is kinetic. The transported time averaged wave power per unit width L of the wave front is

$$\frac{dP}{dL} = c\,T\,H^2,\ c = 976\,WHm^{-3}\,s^{-1}$$

Where 1/T is the frequency and the height H of the wave is twice the amplitude, H=2A. The potential energy gives a lift force to Wave WB and this make the Linear generators move from top to bottom which intern produces electrical energy on accordance with the faradays laws expressed as

$$\epsilon_{ind} = -\frac{d\lambda}{dL} = -N_{COIL}\frac{d\varnothing}{dL}$$

The permanent magnets create a Magneto Motive Force (MMF) in the air gap between the stator and the winding coils as shown in Figure 4.

The System is designed to generate 30 volts ac on full stroke of 85 cm which is the Linear Generators's stroke length with a speed of 10 cm /sec. The Vac voltage is rectified and fed to the battery charging unit for charging the lithium ion batteries. The generation of sinusoidal voltage using linear generator is shown in Figure 5.

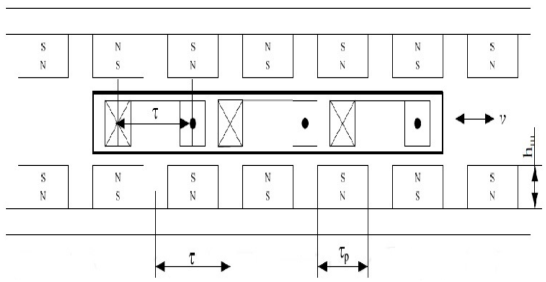

Figure 4. Linear generator working when on wave oscillation.

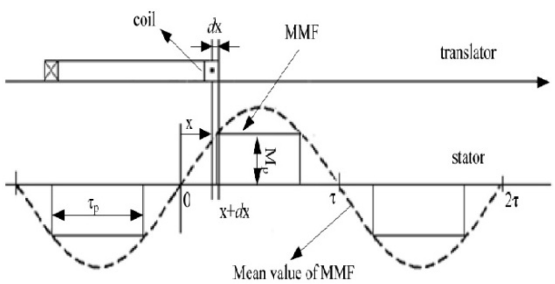

Figure 5. mmf Induced on the linear motion of WB.

4.2 Solar Panel

The WB is covered with solar stickers of CGIS rating for maximum efficiency the rated output of solar panel is 200W with a Panel specification as given in Table 1.

4.3 Thrusters

Two numbers of Thrusters are used for propulsion of the wave bird which is installed on the bottom side of the equipment. When the sea currents are on its peak it is used for generation of power also.

Table 1. Solar Panel Specification

S No	Characteristic	Rating
1	Max System Voltage	1000V
2	Max Peak Power Pmax	190 W
3	CEC PTC Listed Power	169
4	Maximum Power Point Voltage Vmpp	36.2V
5	Maximum Power Point Current Impp	5.25 A
6	Open Circuit Voltage Voc	45.4 V
7	Short Circuit Current Isc	5.44 A
8	Module Efficiency (%)	14.50%
9	Temperature Coefficient of Voc	-0.159 V /°C (-0.35% /°C)
10	Temperature Coefficient of Isc	3.0x10-3 A /°C (0.06% /°C)
11	Temperature Coefficient of Pmax	-0.85 W

Table 2. Thruster Specification

S No	Specification	Rating
1	Rated voltage	24v
2	Speed on load	15,000
3	No load Speed	17,000
4	Rated Current	8A
5	No load Current	0.7 A
6	Power	200W

Specification of the Thruster Motor BY40BL100, cum generator is given below. Thruster specification is shown in Table 2.

5. Instrumentation and Communication for Wave Bird

The wave bird can operate at Medium frequency/High frequency/Very high frequency. It can used in search and rescue mission, receive weather forecast services, vessel traffic and movement informations. All this information can be communicated to wireless coastal station through satellite. Figure 6 shows the communication topology of wave bird with the coastal wireless station.

This chambers consists of various sub modules and units as given in Figure 7.

- Wind Vane Anemometer: It is a device used for measuring wind speed.
- Aquatic Sampling Equipment: This equipment is used to test the chemical and biological nature and also gives information regarding oil spilling in the sea water.

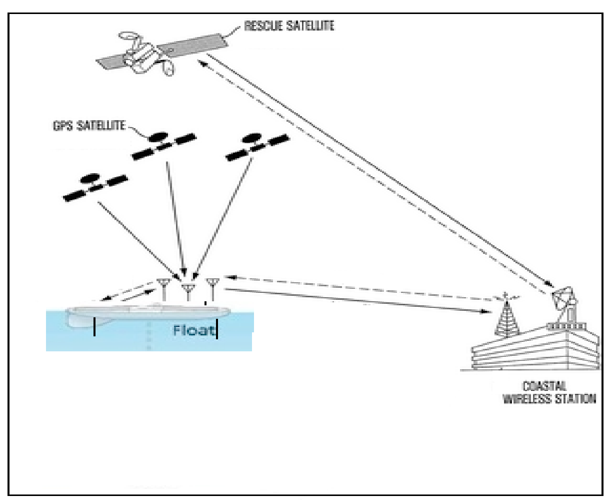

Figure 6. Wave Bird Communication Topology.

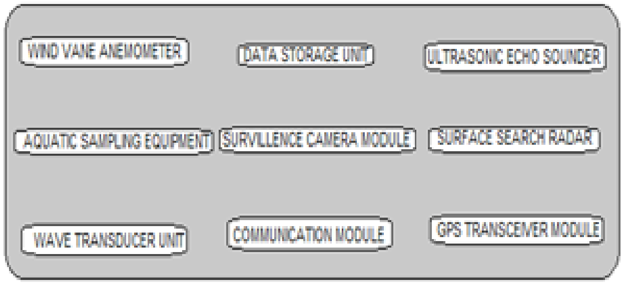

Figure 7. Instrumentation and communication equipment chamber.

- Wave Transducer: It is a device used to measure the wave nature eg: High or Low waves.
- Data Storage Unit: It has inbuilt hard disk and it is a centralised unit used to store all the information.
- Surveillance Camera Module: This module has high resolution stereovision camera for marine surveillance.
- Communication Module: This module transfer information from the wave guider to the coastal station and vice versa.
- Ultrasonic Echo Sounder: This equipment is used to find out the depth of the sea.
- Surface Search Radar: This radar gives information regarding the maritime activities that is take place over the surface of the sea.
- GPS Transceiver Module: This module gives information regarding the geographic location of the wave bird. It can locate the positions in sea with help of satellite information

Various communication and instrumentation equipments required for real time communication with the shore is shown in Table 3.

Marine Surveillance means monitoring the activities, behavior and other changing information in ocean surface.

Table 3. Instrumentation and communication equipment Specification

S No	Equipment Name	Power
1	Wind Vane Anemometer	5W
2	Aquatic Sampling Equipment	3W
3	Wave Transducer	3W
4	Data Storage Unit	10W
5	Surveillance Camera Module	10W
6	Communication Module	30W
7	Ultrasonic Echo Sounder	2w
8	Surface Search Radar	50W
9	GPS Transceiver Module	15W

The main purpose of monitoring

1. Wave bird can mainly used during search and rescue mission.
2. To forecast regarding nature disasters like cyclone, Tsunami and earth quakes etc.
3. To study and understand the chemical and biological nature of the sea water
4. To analyze regarding marine pollutions due to oil spilling
5. To study about the aquatic micro organisms
6. Gives information regarding Vessel movement, Vessel traffic and also can be used in defense for coastal surveillance for identifying enemy vessel movements.
7. Gives information regarding illegal activities takes place at sea.

6. Conclusion

The design and capability of the conventional wave glider system which limited the range of operation is thoroughly studied. The novel concept of wave glider is named as Wave Bird as it has its unique feature of Semi flying in addition to floating. The limiting factors like speed of movement, surveillance ability, low perspective vision, power utilization, precise data handling, monitoring of intruding vessels and IMO regulations has been analyzed and modified in the new design of Wave Bird. The usage of helium gas for reducing the pay load enhances the ability of wave bird to fly for long duration. The proposed design overcomes all the limiting factors like low perspective vision in communication by its capability of fast movement and maneuverability The Wave bird can be deployed for efficient monitoring, surveillance and specially designed for defense application .The real time implementation of the proposed system will give a precise impact of the Wave Bird.

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