© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

Renewable Energy Powered Autonomous Smart Ocean Surface Vehicles (REASOSE)

M. Kamalahasan[1], T. Raghu[2], B. Swapna[1,3]*, K. Saravanan[4], D. Manjula[5]

[1]Centre Head, Artificial Intelligence Lab, Advanced Research Institute,
Dr. MGR Educational & Research Institute, Chennai, INDIA

[2]Research Engineer, Advanced Research Institute,
Dr. MGR Educational & Research Institute, Chennai, INDIA

[3]Assistant Professor, Department of Electronics and Communication Engineering,
Dr. MGR Educational & Research Institute, Chennai, INDIA

[4]Assistant Professor, Department of Electrical and Electronics Engineering,
Dr. MGR Educational & Research Institute, Chennai, INDIA

[5]Assistant Professor, Department of Mathematics,
Sri Ramakrishna Engineering College, Coimbatore, INDIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2022.14.07.001
Received 26 April 2022; Accepted 1 July 2022; Available online 31 December 2022

Abstract: The REASOSE is not just an Ocean surface vehicle, its poly-type smart autonomous propulsion which eliminates the limitations of existing surface vehicles (remotely operated). The renewable energy source always proved to be abundance of availability in the environment, since the power created through renewable source with loss is engineering acceptance which can immobilise the vehicle. But REASOSE is a unique vehicle with poly-type propulsion incorporated with different renewable sources from the environment which furnishes the consistency of the vehicle inevitable. The REASOSE is a smart intelligent system of vehicle that autonomously switch over to the efficient propulsion as per the availability and in kind of any hindrances the vehicle acts smartly and reaches its destination contiguously. The proposed project novelty is not only stick to a line, the proposed vehicle serves to be change over for versatile applications, the vehicle will be incorporated with high definition live transmitted camera serves for coastal surveillance, deep sea monitoring and so on. The integrated CTD, ADCP and other oceanographic sensors can be a changeover in data collection at different area at required region and time. The stack-up space provides the transportation during unconditional or conditional mode of cargo transfer to required destination.

Keywords: Renewable energy source, autonomous vehicle, ocean, underwater vehicle, propulsion, gyroscope, thrust

1. Introduction

REASOSE is an experiment in building an autonomous surface vehicle to breakthrough all the limitations and enlargement of the area of application in vast maritime field activities with long and everlasting endurance. The development of RASSE is poly-type renewable propulsion which drives the vehicle continuously considering all environment conditions, if there is failure of primary propulsion, the smart designed vehicle shifts to secondary

*Corresponding author:swapna.eee@drmgrdu.ac.in

renewable propulsion source and in typical case if secondary propulsion source fails habitually to tertiary propulsion. Significantly the proposed vehicle will be serving as a saviour in maritime field application for Defence Surveillance, oceanography, hydrography and cargo shipping & so on. The proposed project can be replacement of moored buoys in collection of sea parameters and sea vehicle movement activity at particular locations by cruising and collecting data on different locations at different seasonal time which saves energy, labour and cost. The virtual live transmission incorporated camera will be a coastal surveillance vehicle and can be deep sea monitoring also. Thus, the project will have exposure to design, simulation, prototype development and will cruise test at sea by collecting data parameters and co-relate to study with satellite data. This advanced ASV - REASOSE can serve a multiple of roles from security to oceanographic data collection to data mining.

The vehicle will be equipped with Poly-propulsion source system, the primary propulsion will be from solar energy, and thus the vehicle will be equipped with 500 watts energy producing solar panel cells to drive the required bollard thrust 25-kgf. The net power generated form the solar panel cell is 70% of net power generated, which cruise the vehicle with 3-5 knots speed on day with add-on battery will be charging for back-up when radiation source decreases. The thin micro structure solar panel cells are more endurance and flexible up to 30 degree of bending which condenses the area of occupancy. The power from the solar panel drives the propulsion has availability during day light. As the intensity of the power from solar panel reduces, the play of poly-propulsion begins by switching over to the secondary propulsion source.

The design proposed as poly-renewable energy system, whereas exiting research on single source, that too mostly on solar energy as renewable source, the energy source always proved to be abundance of availability in the environment, since the power created through renewable source with loss is engineering acceptance which can immobilise the vehicle. But the proposed REASOSE as poly renewable system has switch over battery circuit system with BMS for monitoring each battery power unit to switch over from one source to other successfully.

2. Related Work

This paper proposes the design of a navigation system for an unmanned underwater vehicle that is powered by renewable energy sources such as solar energy. This navigation system has two main functions- trajectory tracking and obstacle avoidance which is done by using adaptive neuro-controllers. The use of renewable sources such as solar panels help it last or work for longer durations making it more efficient for underwater missions [1].

This research discusses the collision avoidance for Underwater Surface Vehicles (USVs) with respect to its Navigation, Guidance and control systems. It highlights the current limitations in the ODA system and provides suggestions and protocols to improve the state of the Obstacle Avoidance Architecture and the NGC system [2].

The design of a solar powered Autonomous Underwater Vehicle (AUV) is presented in this paper along with its many functions and advantages that not only include surveillance and monitoring but also overcome the limitation of battery life by using solar panels to recharge batteries daily. It can operate at sea for long durations i.e., even months thereby increasing the effectiveness of such AUVs [3].

This paper presents a case study of Pakistan regarding the use of renewable energy sources in the field of robotics. Robotics in itself is already a quite vast and advanced form of technology and researches have showed that such technology when paired with renewable green energy sources produce even better results and accomplishments in the field as well as being environmentally friendly [4].

This paper proposes the use of an Autonomous Surface Vehicle (ASV) for multi-domain mapping of offshore wind farms to ensure better safety and efficiency of those farms. This design seeks to provide an accurate reconstruction and representation of the two domains by using navigation sensors, GPS and perception sensors and 3D Lidar and a Multibeam echosounder sonar (MBES) equipped in it and to enhance real time visualization of inspection tasks [5].

This work focuses on the Autonomous Surface Vehicle ROAZ which is capable of performing various precise path following while carrying equipment for bathymetry surveys and operations that are high in demand and discusses both its design and functions [6].

The development of Autonomous Underwater Vehicle (AUV) has been very efficient and has contributed a lot in the field of scientific and underwater researches. Which hence has led to a lot of focus on how to improve the already existing designs and architecture for better and efficient results. This paper presents a general review on the instrumentation and measurement systems embedded in AUVs. It also discusses its further development and uses while also highlighting its current mapping, navigation and sampling systems [7].

A new project called H2020 ENDURUNS is introduced in this work with the intention of developing new applications for seabed surveys and exploration with its hybrid approach involving an Autonomous Underwater Vehicle (AUV) along with an Unmanned Surface Vehicle (USV). It is also aimed towards providing an accurate mapping or evaluation of the critical offshore infrastructures thus contributing not only towards increasing the deep-sea knowledge but also providing sustainability to the global economy [8].

This study introduces the idea of designing a fuel-cell powered Unmanned Surface Vehicle (USV) to verify the use of fuel cells in the development of surface vehicles. To do this, a catamaran type USV powered by hydrogen fuel cells and lithium-ion batteries has been developed. It is equipped with an automatic control system with a GPS and an INS, along with a novel hybrid power control algorithm for more efficient control [9].

This paper gives a review on the different wireless power transmission technologies while giving guidelines and suggestions for the development of an ideal design of wireless charged EV in terms of efficiency, effectiveness and economically friendly. It gives a few suggestions for integrating renewable energy sources with wireless charging stations to not only conserve energy but also to improve thermal efficiency [10].

This paper focuses on a case study in Menorca, a Balearic touristic island belonging to Spain regarding the potential of e-mobility to support renewable energy (RE) grid integration. For this purpose, the use of Plug in Energy Vehicles (PEVs) is discussed in that context and the need to minimize the Permanent Battery Energy Storage System (BESS) is discussed [11].

This paper presents several guidelines and algorithms for long endurance of ASVs involving energy-efficient station keeping while keeping both ideal and realistic environmental factors in mind. The performance and pros cons of these algorithms are compared based on the numerical simulations of the ocean to visualize the design of such long endurance marine ASV [12].

This study attempts to further analyse and present the idea of integrating renewable energy sources such as solar, wind and geothermal energies with already efficient combined heat & power configurations to develop more environmentally friendly systems. These renewable resources were thoroughly discussed in this paper in the context of integration into the CHP systems along with the current state-of-art researches [13].

This book describes the potential for Maritime informatics in the field of shipping industry. It analyses the improvements that can be made by introducing new required technologies and the application of information systems to increase efficiency and sustainability of the shipping industry while also discussing the various shipping companies themselves [14].

3. Proposed Autonomous Smart Ocean Surface Vehicles

The Autonomous underwater vehicle has to be designed for several applications with smart sensors, several electronic components, automotive software, and GPS system using in house GUI system. The vehicle drive is propelled with secondary renewable propulsion with wind turbine; the vertical axis wind turbine will be producing 100 Watts of power which thrust the vehicle in night time at 10% lesser speed than from solar energy source. The multi wind turbines in series integration may also considerably serve as efficient power source to drive the vehicle. The open ocean environment may lead to many hindrances if on so the secondary propulsion fails; the smart REASOSE will switch over to the tertiary propulsion source.

The designed vehicle may lead to face typical scenario of failure of the secondary source of propulsion, thus the system was equipped with blade duct, which provides to cruise with current speed by manoeuvre smartly. The blade duct convergent section increases the velocity at ratio of 2:1, thus the water cut in the convergent duct creates a whirl motion that drives the propeller blade in the duct unit. The tertiary propulsion controls the vehicle direction change through keel and rudder by smart intelligence in orderly to reach the planned destination successfully. At any stage, the vehicle will reach autonomously by facing all hindrance smartly.

Thruster, which produces, thrust of 12.5 kg each and two numbers of thrusters can be used. This thruster is extensively used in many ROVs and AUVs specifically for marine robotics. UV resistant polycarbonate injection moulded plastic. The core of the motor is sealed and protected with an epoxy coating and it uses high-performance plastic bearings in place of steel bearings that rust in saltwater. This thruster uses high quality steel, aluminium to counter corrosion and plastic parts. A specially designed propeller and nozzle provides efficient, powerful thrust while active water-cooling helps to cool the motor. Water flows freely through all parts of the motor and it can handle even high pressure.

3.1 Thruster Specifications

T200 Thruster is the world’s most popular underwater thruster for ROVs, AUVs, surface vessels, and more! Its patented flooded motor design makes it powerful, efficient, compact, and affordable. The T200 is in use on thousands of marine robotic vehicles around the world including the BlueROV2.

3.2 Ping Sonar Sensor

The Ping device emits a brief 115 kHz acoustic pulse from the transducer at the face of the device. The device then listens back and measures the strength of returned acoustic energy. As the acoustic sound waves travel through water they reflect or echo off of solid objects and then travel back to the device. The Ping then calculates the distance to the object with the equation.

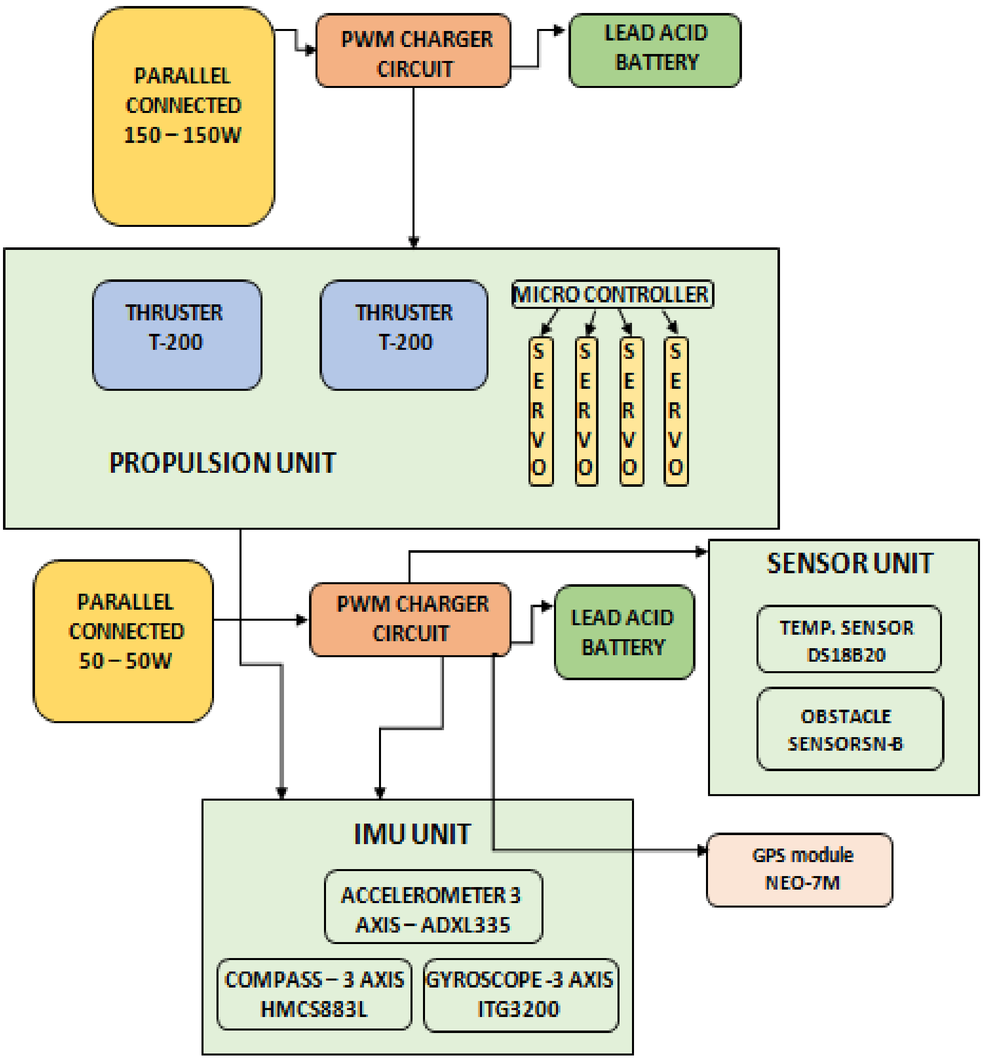

Fig. 1 - Autonomous smart ocean surface vehicles system

3.3 Temp-Sensor

The Bar30 pressure sensor is a high-pressure, high-resolution pressure sensor that is sealed from the water and ready to install in a watertight enclosure on your ROV or AUV. With 0.2 mbar resolution, it has an amazing depth measurement resolution of 2mm in the water column.

The sensor is the Measurement Specialties MS5837-30BA, which can measure up to 30 bar (300m/1000ft depth) and communicates over I2C. It operates on 3.3V I2C voltage but can accept power input up to 5.5V.

3.4 AUV Sub Systems & Specification

The Lumen Subsea Light is a blindingly bright LED light for use on ROVs, AUVs, and other subsea applications. We designed this underwater light specifically for this purpose and it has a few neat features are Fully dimmable control using a PWM servo signal (1100-1900 µs), Simple on/off control with no signal needed, Automatic, smart over-temperature compensation for maximum light output and safety in air, New in R2: 500m depth rating, Daisy-chainable to connect multiple lights from a single connection.

3.5 Lithium-ion Battery

The Lithium-ion Battery (14.8V, 18Ah) is a high-capacity custom battery pack made from high quality 18650 lithium-ion cells designed for use in the BlueROV2. This 4S (14.8V) battery has a nominal capacity of 18.0Ah, plenty for up to 4 hours of continuous moderate use on the BlueROV2. The lithium-ion cells the battery is comprised of have excellent performance characteristics, as well as a high tolerance for accidental mishandling.

The Lithium-ion Battery (14.8V, 18Ah) is a high-capacity custom battery pack made from high quality 18650 lithium-ion cells designed for use in the BlueROV2 (Remotely Operated vehicle of Blue-Robotics, USA company). This

4S (14.8V) battery has a nominal capacity of 18.0Ah, plenty for up to 4 hours of continuous moderate use on the BlueROV2. The lithium-ion cells the battery is comprised of have excellent performance characteristics, as well as a high tolerance for accidental mishandling.

3.6 World Sunlight PWM Solar Charge Controller

WSSC-2 Solar Charge Controller is a photovoltaic (PV) charge controller that tracks the PV array to deliver the available current for charging batteries. When charging, the Controller regulates battery voltage and output current based on the amount of energy available from the PV array and state-of-charge of the battery. WSSC Solar Charge Controller can be used with 12/24 VDC battery systems, Max PV input 100VDC.

4. Discussion on Experimental Outcomes

4.1 Hull Fabrication

The Hull fabrication has different stages and evaluation on various parameters at each stage during the fabrication. Initially the fabrication was started with pattern making for mould of fibre glass structure. The figure 2 shows the pattern of hull where the initial pattern was made and dimensional accuracy are made to bring near to the tolerance and draft areas were studied to release mould hassle free condition.

From the pattern the fibre glass layer up as per the matrix design evaluation a study and mould operation of the catamaran hull of symmetrically carried out for symmetric stabilize fabrication to limit the run-out of the trajectory as shown in figure 3.

Fig. 2 - Hull pattern

Fig. 3 - Moulded hull structure

After the release of the mould and the dimensional and drop test on water were evaluated at this stage to ensure the design reliability and endurance strength of the ocean surface vehicle. The figure 4 shows the furnished final product that has been fabricated and further evaluation for cruise test to be carried out the vehicle was ready.

Fig. 4 - Furnished hull

4.2 Working Principle

4.2.1 Hull Design

The hull design of REASOSE was developed in wellbeing precise design as per DNV standard. It is compared and parameterized with various design and studied & evaluated with optimized design with Finite Element evaluation. The REASOSE Hull design is evaluated on below parameters, which are discussed briefly and shown in figure 5 and figure 6. DNV (Det Norske Veritas) standard deign on Hull structure detailed on hull design for rule length, breadth, depth and draught. The structural design on the vehicle design forepart, aft part and central hull part system have been considered with detailed designed rules have been studied.

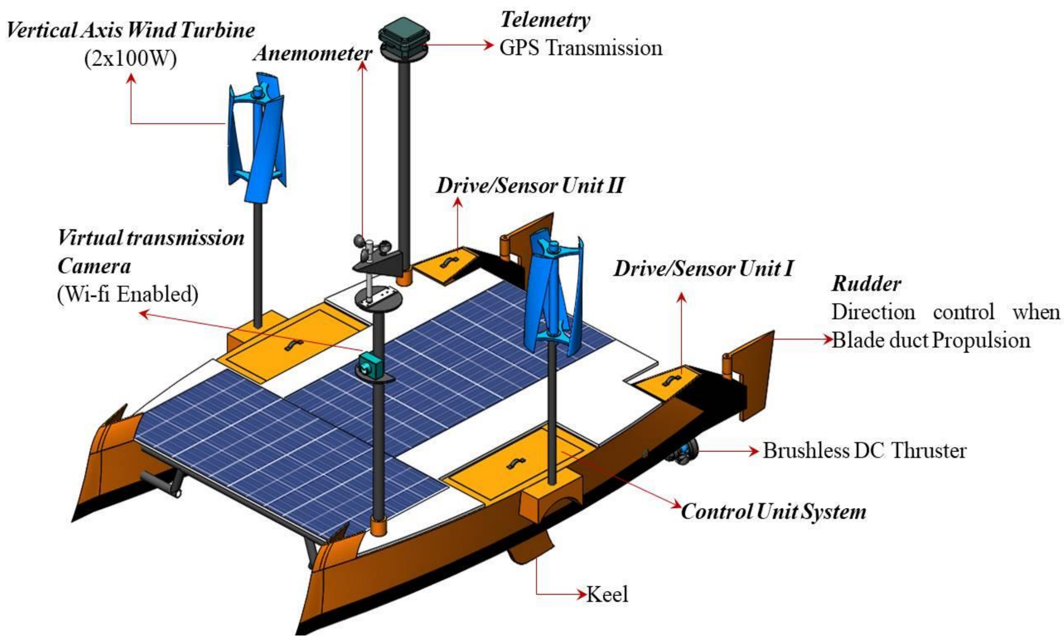

Fig. 5 - Electronic algorithm design in testing platform

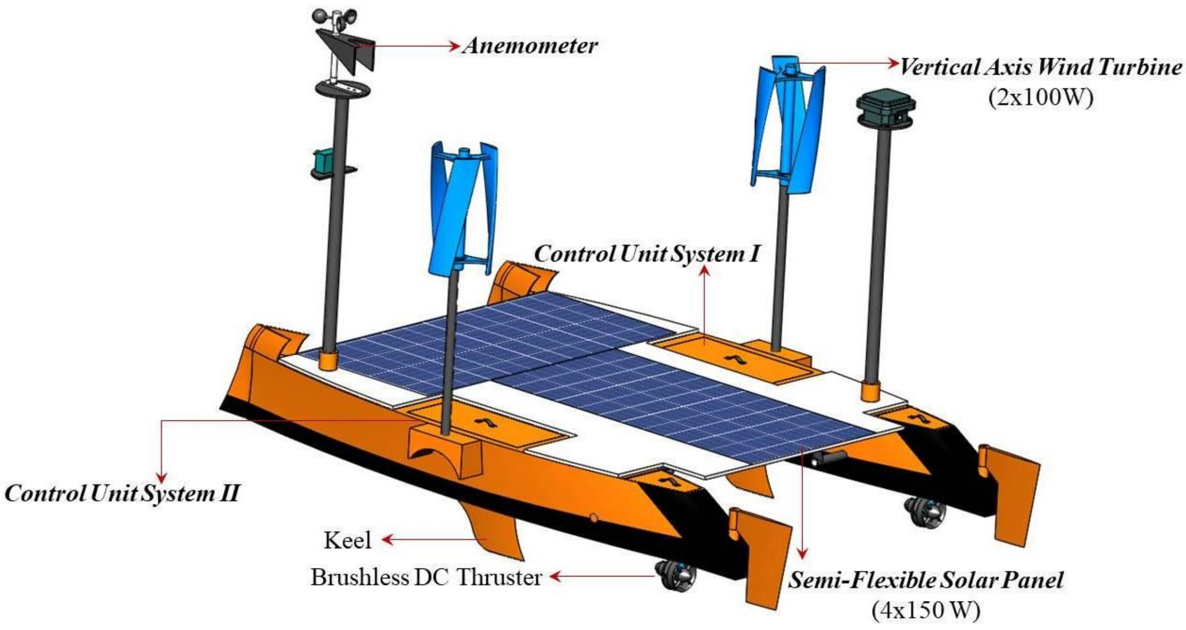

Fig. 6 - Mechanical 3-d hull structure design module connection in testing platform

4.2.2 Effective Trajectory Design

The trajectory of the REASOSE was base line in the design parameters; which decides the effective trajectory of the vehicle. The initial contact of the surface vehicle which strikes to cut water in piercing to cruise make effective in decreasing the drag of the vehicle in dynamics.

The hydrodynamic diffraction study on the trajectory of the vehicle was evaluated with optimized- trajectory design with Finite Element Analysis through ANSYS-AQWA, the hydrodynamic diffraction study with time response on the ocean environment stipulates the vehicle base inline structural design has an effective trajectory to cruise the vehicle effectively for reliable has an autonomous surface vehicle. The investigation of the effects of wave, wind and current on the surface vehicle design evaluates the structure design and analysis be performed efficiently in terms of time and cost. The powerful range of modelling and analysis capabilities enables the rapid assessment of many design alternatives, in particular early in a project, significantly reducing overall project costs and timescales. ANSYS-Aqwa is FEA (Finite Element Analysis) Model for simulation study, where Aqwa is a word describe abouy the aqua floating simulation on various environmental conditions. The environmental loading taken into the account are:

- Constant wind and current
- Regular and irregular (spectral) waves
- Wave surface time history
- Wind time history
- Current profile
- Wind spectrum.

The parameters of environmental loading are as per the ocean parameters of “Arabian Sea and Bay of Bengal” respectively- wind speed of 5 knots to 10 knots, 0.5m to 1m of wave height time transient at stable current profile based environmental parameters the trajectory design was optimized and evaluated to the effective hull design.

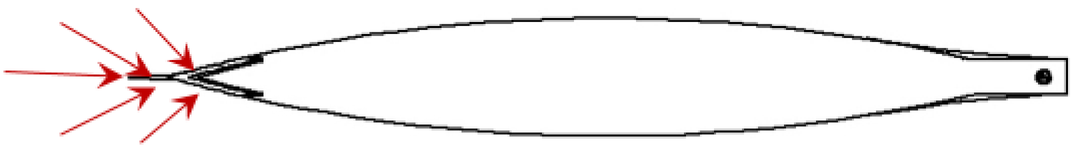

Fig. 7 - Initial water cutting trajectory design of hull- top view

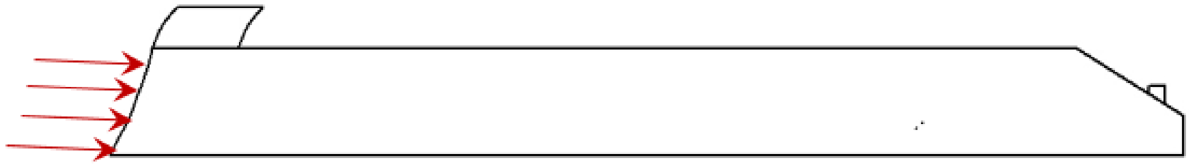

Fig. 8 - Initial water cutting trajectory design of hull-front view

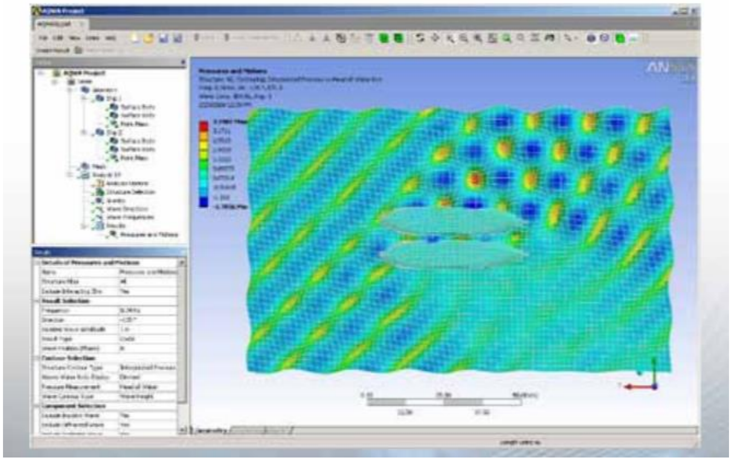

Fig. 9 - Hydro dynamic diffraction study through ANSYS-Aqwa

The bow strident to diverted V-blend edge design in Top view and front view as shown in figure 7 and figure 8 pierces in water cutting has dynamically while cruising that results the solution of hydrodynamic simulation study in figure 9 has efficient for less drag hull design. The hull design is about the structural rigidity and composite lay-up strength design of the hull and positioning of various electronic components as shown in the figure. Effective trajectory design is about the streamline trajectory profile of hull for suitability of the sea state condition and fluid flow deign for laminar flow without any vorticity.

4.2.3 Low Drag & High Stability Design

The effective trajectory design of the vehicle leads to catamaran hull shaped design to enhance more effective in high stability and further less drag effective design. Thus in today scenario; the stabilised design of the effective trajectory design of ocean surface vehicle for less drag coefficient have been evaluated with various optimized design through Finite Element evaluation study on ANSYS fluent application by Reynolds-Averaged Navier-Stokes (RANS) Equation.

The solution of problems involving determination of resistances using Computational Fluid Dynamics (CFD) analysis is now becoming tractable due to enhanced accessibility to high performance computing. Determination of the resistance characteristics of the REASOSE is one of the most important studies in Naval Architecture, Offshore and Ocean Engineering. Today, several CFD tools play an important role in the design of the ship hull forms. CFD has been used for the analysis of ship resistances, sea keeping, maneuvering and investigating the variation in resistance encountered due to changes in the ship hull resulting from variation in its parameters.

The major objective of this work is to collect data of the vehicle to enable its characterization and thereafter to use this data to perform CFD analysis of its hull form to understand its resistance characteristics. Specification of testing platform as shown in table. 1.

The study on analytical modelling and simulation modelling of the vehicle, the drag, vortices and velocity cut plots will be studied in details through **ANSYS Fluent** applying Reynolds-Averaged Navier-Stokes (RANS) Equations in FEA method. Drag force simulation validation study as shown in table. 2.

Table 1 - Specification of testing platform

Length	2 metres
Beam Span	1.5 metres
Height	2 metres

Draft	0.15 metre
Speed	Up to 5 knots
Endurance	±30 Days
Control	Autonomous Control through GPS
Solar Panel System	4 High efficiency panels generating peak electrical power of 500 W
Wind Turbine System	Lightweight three blade system generating a peak output power of 100 W
Blade Duct System	Light Weight three blade duct thrust through current speed
Sensor options	CTD; ADCP; Obstacle; Pollution Measure
Live Transmission	4 K HD Camera with Wi-Fi, Antenna Transmission

The current typical design of the vehicle analytical and simulation results is correlatively analysed and shown in figure 10 and figure 11.

Table 2 - Drag force simulation validation study

Constrained Current Velocity	Analytical Result of Drag Force, N	CFD Simulation Result of Drag Force, N	Percentage of Error
0.5	7.87	6.94	11.72
1.0	31.49	27.49	12.69
1.5	70.86	62.52	11.76
2.0	125.98	111.10	11.80

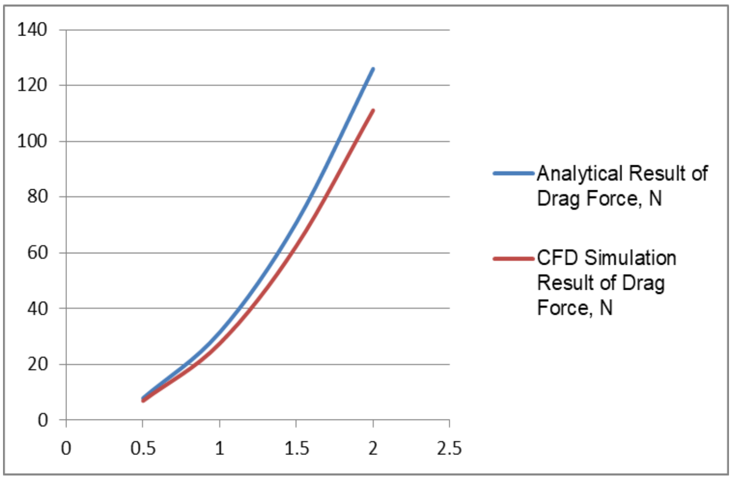

Fig. 10 - Analytical (vs) CFD simulation result drag force comparison

Table 3 - Bollard thrust simulation validation study

Constrained Current Velocity	Analytical Result of Bollard Thrust (kg-f)	CFD Simulation Result of Bollard Thrust (kg-f)	Percentage of Error
0.5	1.36	1.20	11.75
1.0	5.44	4.80	11.76
1.5	12.23	10.79	11.77
2.0	21.75	19.19	11.77

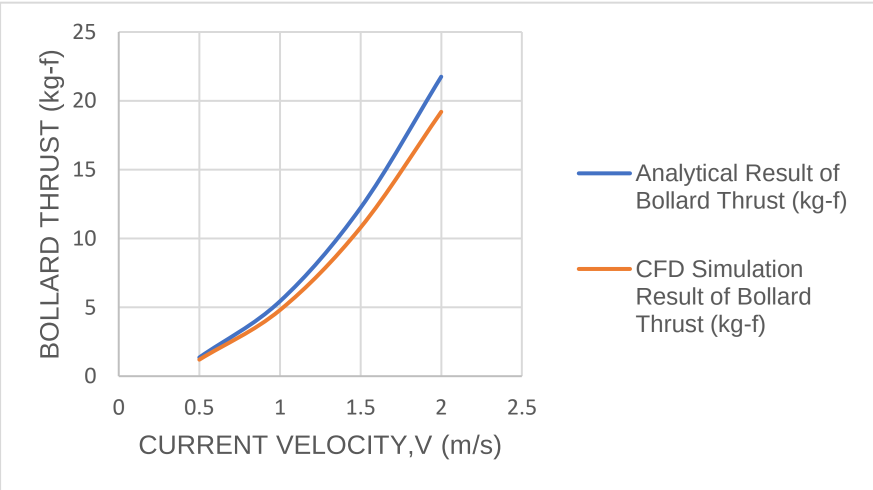

Fig. 11 - Analytical (vs) CFD simulation result bollard thrust comparison

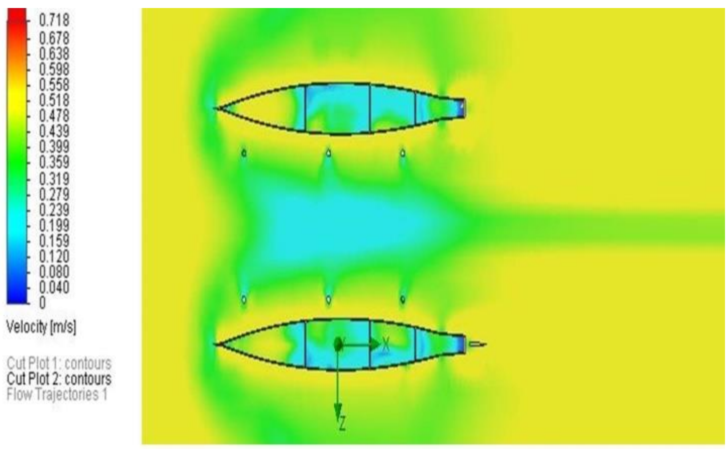

Fig. 12 - Cut-lot at current velocity 0.5m/s

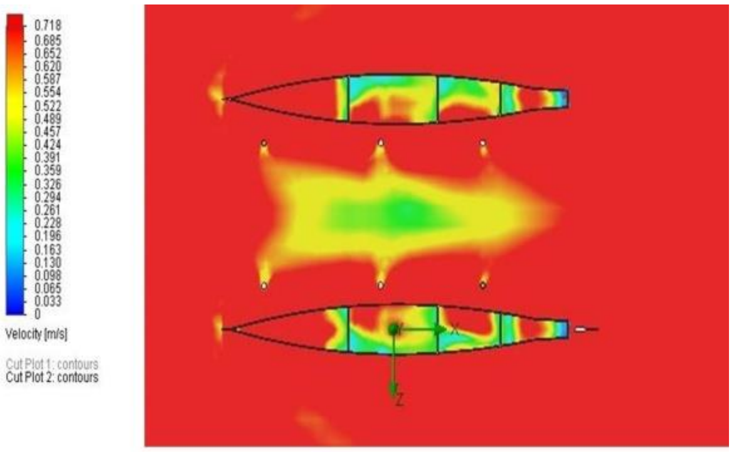

Fig. 13 - Cut-plot at current velocity 0.5m/s

The correlated study behaves to be nominal values and the cut plot velocity shows the high stream current gets dissipates and thus the vehicle thrust as effectively and very small number of vortices would be a negligible as shown in figure 12 and figure 13. The evaluation of the optimized design in stabilized behavior in Ocean environment.

4.2.4 Buoyancy and Instrument Housing Design

The vehicle owns less in weight in water and too in air with effective pay-load design, the vehicle was designed with 35kg weight in air 27.6kg in water which buoyant with 150 kg has payload. The REASOSE catamaran hull of each has 4 parted portions. The first and third parted portion of the vehicle is buoyant portion filled with poly-urethane foam which has buoyancy of 45 kg and 30 kg respectively. The second and fourth parted portion is designed stack-space for instrument with battery to occupy in wellbeing. The instrument housing portion is water leak resistant design which does not pursue water entry and where the instrument housing enclosure has been provided with pressure relief valve (PRV) of 1.1 bar capacity in order to ensure the safety of forming of hydrogen gas may release. The wiring of all instrument is designed perfectly with underwater resistant connectors such that all cabling is well-being in the ocean surface vehicle. Payload is 150 kilogram.

4.3 Study on Composite Glass Fibre Matrix Pattern

REASOSE built by fibre glass; the vehicle structure is evaluated for good resistance in load for harsh environment for naval architecture and ocean engineering applications. Fibre glass with proper layer of matrix segments with effective resin makes the reliability and endurance of the vehicle. REASOSE structure was a S-Glass Fibre (**S**tructural Glass Fibre), which enhance the structural strength and reliability, even though the S-glass fibre are strong enough the selective style of matrix arrangement and resin would be the key players in the bonding of the fibre for effective maximum strength in the structure.

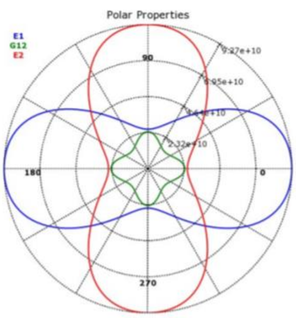

Fig. 14 - Stack-up layup of ply

The certain DION FR-9300 Resin compatible to sea parameters as per ASTM E-84 was selected for the design. The lay-up of each ply of fibre glass at 45°, 135°,90°,270° of 4x4 stack-up matrix formation of medium through resin of four stack-up sub-laminate layer of matrix as shown in figure 14 was designed through ANSYS ACP pre-processing and analyzed & evaluated through ANSYS ACP-post processing. The stress induced on the sub-laminate layer matrix pattern of glass fibre was endurance within the limit.

The certain DION FR-9300 (Brominated Bisphenol) Resin compatible to sea parameters as per ASTM (American Society for Testing and Materials) E-84 was selected for the design. The lay-up of each ply of fibre glass at 45°, 135°,90°,270° of 4x4 stack-up matrix formation of medium through resin of four stack-up sub-laminate layer of matrix as shown in figure 14 was designed through ANSYS ACP pre-processing and analyzed & evaluated through ANSYS ACP-post processing. The stress induced on the sub-laminate layer matrix pattern of glass fibre was endurance within the limit.

5. Testing and Result Analysis

5.1 Ballasting Test

Fig. 15 - Ballasting test without load

Fig. 16 - Ballasting test with load

The REASOSE was evaluated on real-time condition behavior after every pay-load of the vehicle was incorporated and peak environment load condition at instant time response of the vehicle was studied; that the metacentre and centre of buoyancy of the hull structure attains a stable and original position. The figure 15 and figure 16 shows the ballistic evaluation test on a pool and stability of the vehicle at further any load also stabilizes automatically the metacentre and centre of buoyancy are in stable position.

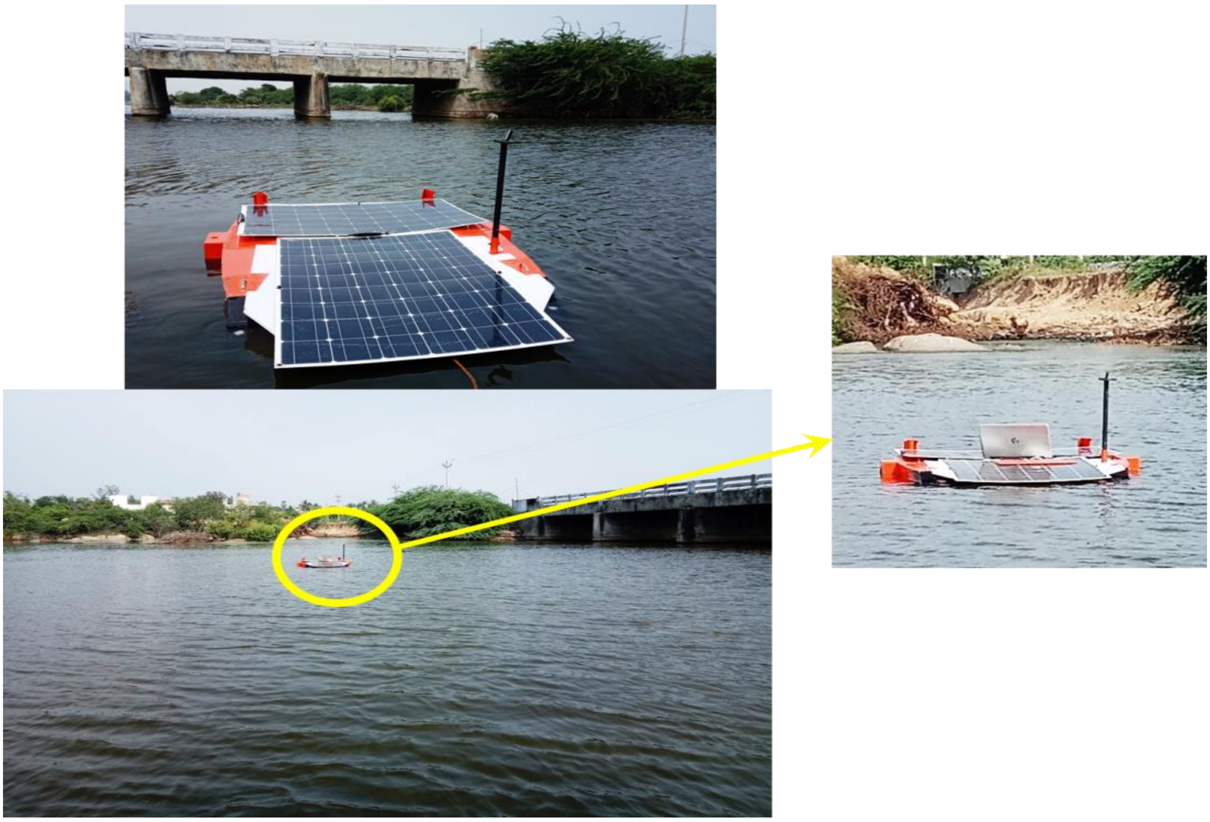

Fig. 17 - Real-time testing at Muttukadu, ECR & Chennai

Endurance- 1 Hrs (Without Panels)

6 Hrs (With Panels)

Volume of Water Displacement- 0.05 m3

Propulsion Unit- Blue Robotics T200Thruster. Real time test was done in Muttukadu, ECR and Chennai as shown in figure 17.

5.2 Analytical Engineering Simulation and Validation

Generally, the simulation study is categorizes into three categories which are basically the pillar of the analysis. They are Verification, Validation and Uncertainty quantification.

Verification: Is the computational method implemented correctly?

Validation: Are we solving the right equations?

Uncertainty Quantification: Error bars in scientific predictions.

Computation cannot be truly predictive without the coupling to physico-chemical models and experiments. This coupling is precisely the verification and validation process. The study on analytical modelling and simulation modelling of the vehicle, the drag, vortices and velocity cut plots will be studied in details. The current typical design of the vehicle analytical and simulation results are correlatively analyzed. The correlated study behaves to be nominal values and the cut plot velocity shows the high stream current gets dissipates and thus the vehicle thrust as effectively and very small number of vortices would be a negligible.

5.2 GPS Result

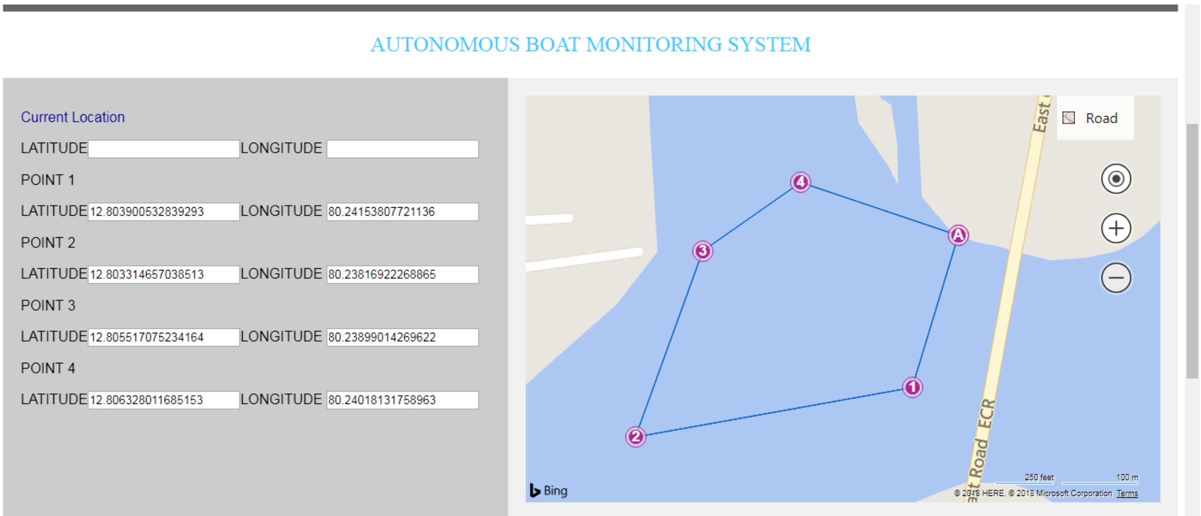

Fig. 18 - In house GUI system

Latitude and Longitude with the respective direction using GPS system as shown in figure 18. In house GUI system gives the directional view of the underwater vehicle, which is very useful to track the direction.

6. Conclusion

The surface water autonomous vehicle is made with the combination of the various electrical and electronic components. The outer body of the boat is made of fiber material. The main advantage of this boat is it drives on its own using the solar energy without any human aid. The waypoints can be set and the programmer can decide the destination of the vehicle. The location of the vehicle can be tracked using GPS, it will be useful to find the boat in case of any accidents. Even though, many other countries made these kinds of surface water vehicle but this is going to be our country's product.

References

[1] Garcia-Cordova, F., & Guerrero-Gonzalez, A. (2013). Intelligent Navigation for a Solar Powered Unmanned Underwater Vehicle. International Journal of Advanced Robotic Systems, 10(4), 185. doi:10.5772/56029

[2] Campbell, S., Naeem, W., & Irwin, G. W. (2012). A review on improving the autonomy of unmanned surface vehicles through intelligent collision avoidance manoeuvres. Annual Reviews in Control, 36(2), 267–283. doi: 10.1016/j.arcontrol.2012.09.008

[3] Ageev, M., & Richard Blidberg, D. (2002). Solar Powered Autonomous Underwater Vehicle. Technology and Applications of Autonomous Underwater Vehicles, 59–76. doi:10.1201/9780203522301.ch4

[4] Dincer, I. (2000). Renewable energy and sustainable development: a crucial review. Renewable and Sustainable Energy Reviews, 4(2), 157–175. doi:10.1016/s1364-0321(99)00011-8

[5] Campos, D. F., Matos, A., & Pinto, A. M. (2020). Multi-domain Mapping for Offshore Asset Inspection using an Autonomous Surface Vehicle. 2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC). doi:10.1109/icarsc49921.2020.9096097

[6] Ferreira, H., Almeida, C., Martins, A., Almeida, J., Dias, N., Dias, A., & Silva, E. (2009). Autonomous bathymetry for risk assessment with ROAZ robotic surface vehicle. OCEANS, EUROPE. doi:10.1109/oceanse.2009.5278235

[7] Sanchez, P. J. B., Papaelias, M., & Marquez, F. P. G. (2020). Autonomous underwater vehicles: Instrumentation and measurements. IEEE Instrumentation & Measurement Magazine, 23(2), 105–114. doi:10.1109/mim.2020.9062680

[8] Marini, S., Gjeci, N., Govindaraj, S., But, A., Sportich, B., Ottaviani, E., Papaelias, M. (2020). ENDURUNS: An Integrated and Flexible Approach for Seabed Survey Through Autonomous Mobile Vehicles. Journal of Marine Science and Engineering, 8(9), 633. doi:10.3390/jmse8090633

[9] Sohn, S.-I., Oh, J.-H., Lee, Y.-S., Park, D.-H., & Oh, I.-K. (2015). Design of a Fuel-Cell-Powered Catamaran-Type Unmanned Surface Vehicle. IEEE Journal of Oceanic Engineering, 40(2), 388–396. doi:10.1109/joe.2014.2315889

[10] Joseph, P. K., & Elangovan, D. (2018). A review on renewable energy powered wireless power transmission techniques for light electric vehicle charging applications. Journal of Energy Storage, 16, 145–155. doi:10.1016/j.est.2017.12.019

[11] Raveendran, V., Alvarez-Bel, C., & Nair, M. G. (2020). Assessing the ancillary service potential of electric vehicles to support renewable energy integration in touristic islands: A case study from Balearic island of Menorca. Renewable Energy, 161, 495–509. doi:10.1016/j.renene.2020.06.083

[12] Oh, H., Kim, S., Tsourdos, A., & Savvaris, A. (2019). Comparison of station keeping strategies for long endurance autonomous surface vehicle. Journal of Marine Science and Technology, 25(1), 13–25. doi:10.1007/s00773-019-00628-1

[13] Bagherian, M. A., & Mehranzamir, K. (2020). A comprehensive review on renewable energy integration for combined heat and power production. Energy Conversion and Management, 224, 113454. doi:10.1016/j.enconman.2020.113454

[14] Lind, M., Ward, R., Bergmann, M., Haraldson, S., Zerem, A., Hoffmann, J., & Eklund, E (2020). Maritime Informatics for Increased Collaboration. Maritime Informatics, 113–136