

TRAVISIONS

TRA VISIONS 2024

Final Project Template - This template is to be used for submitting the final version of the project. The final deliverable should be submitted by the 31st of October 2023

Idea Number:

C2024 - 74

PILLAR / TRANSPORT MODE				
ROAD ☐	RAIL ☐	WATERBORNE ☒	AIRBORNE ☐	CROSS MODAL ☐
Project Related to:	☐ RA1: Safe & Inclusive Transport ☒ RA2: Sustainable Mobility of People & Goods ☐ RA3: Collaborative Digitalization ☒ RA4: Efficient & Resilient Systems			

Project Title: HYCata-HOPE (Powered by Hydrogen)

TRAVISIONS

This project has received funding from the
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Research and Innovation Programme
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1. Introduction

HYCata-Hope (Powered by Hydrogen) is a zero-emission, environmentally friendly, zero-emission cruising catamaran that uses Sodium Boron Hydride as fuel and promotes the use of renewable energy sources. The Paris Agreement aims to mitigate climate change and its risks globally, and the maritime sector is expected to contribute to this goal. The Paris Agreement directs companies to new investments and research to reduce greenhouse gas emissions and reduce carbon emissions in order to keep the increase in global average temperature below 2 degrees Celsius compared to pre-industrial levels and to limit the increase to 1.5 degrees Celsius as much as possible (Republic of Turkey Ministry of Foreign Affairs, Accessed 20 July 2023). This catamaran has the potential to reduce carbon emissions and their impacts. And in these times when green energy is on the agenda, it could be a good alternative for companies.

2. Selection of research area

The transportation sector in which the project is investigated is waterborne transportation.

Within the scope of this project, zero emission and renewable energy were selected as research topics.

Among the research topics, research was conducted under RA2 and RA4 topics.

The reason for choosing this research is to create a clean propulsion system with zero emissions thanks to the catamaran recreational boat and Sodium Boron Hydride fuel system.

Waste wind turbine blades were used in the production of the catamaran hull. With this, it is aimed to create a renewable resource from turbine blades that have the potential to produce high amounts of waste.

The designed catamaran has many innovative ideas. First of all, Gate Rudder was used as the rudder system. Gate rudder system is a very important system for saving energy and increasing maneuverability.

Liquid glass application was chosen as an environmentally harmless system to prevent the accumulation of organisms and substances underwater. This system will also reduce friction and corrosion. Which will be able to save fuel on the ship.

3. Literature Survey

90% of global trade is carried out by sea (Çalışkan, 2019). Considering the share of the maritime sector in trade, pollution caused by emissions from fossil fuels used in ships reaches dimensions that threaten nature and brings many problems such as global warming. In addition, the fact that it takes many years to obtain fossil fuels and does not promise a future in terms of fuel needs due to the world's growing population has pushed people to research on renewable energies and alternative fuels. Especially in this process where the energy transition is important, the dissemination of green energy practices in yachts, which we can call small-scale, is very important in terms of leading the decarbonization of other components of the maritime sector. In this context, hydrogen, which is an environmentally friendly alternative fuel, has a high potential for efficiency and is also found in high amounts in nature, stands out (Bektaş et al., 2021).

Hydrogen stands out as the most usable fuel among alternative fuels. Its high energy density, the fact that it does not create carbon emissions and creates only water as waste, is abundant in nature, does not create noise pollution and vibration make hydrogen advantageous compared to many alternative energy systems (Gayberi, 2015). In addition, problems such as storage, safety and transportation pose obstacles to the use of hydrogen in vehicles. Storage is a big problem for hydrogen because hydrogen takes up a large volume in gaseous form (Gayberi, 2015). Compression requires high energy. Storage in the form of ammonia, one of the storage options, involves the process of converting hydrogen into a gaseous state and stores hydrogen in liquid form. Ammonia and methanol also pose safety concerns. Ammonia has a high toxicity potential. The best way to store hydrogen is in the form of NaBH₄ (sodium boron hydride). NaBH₄, a boron compound, contains 10.6% hydrogen by weight, which is higher than other alternative compounds (Bilici, 2004). Although NaBH₄ storage systems are larger and heavier, they are potentially applicable on ships. NaBH₄ is a more preferable method due to its high storage capacity, **safer storage system and energy efficiency**. However, NaBH₄ is an important chemical compound containing boron. **Turkey ranks first in the world in terms of boron resources and has 73% of the world's total boron reserves (Yenmez, 2009)**. Boron is considered as a "Strategic Mineral" by the USA and NATO. Boron is used in plastics, industrial fiber production, tire and paper industry, agriculture, nuclear power plants, rocket and aircraft fuels, computer and mobile communication devices, and cancer cell treatment. In addition, boron mineral has the potential to be used as fuel in land and sea transportation vehicles. In other words, boron has a versatile usage area in many sectors such as defense industry, energy sector, communication tools, chemical industry, machinery industry, nuclear industry, transportation vehicles, space and aviation sector (Yiğitbaşıoğlu, 2004; Kırılı, 2008).

4. Proposed Solution-Description of Idea

HYCata-Hope is a CE certified luxury cruising catamaran that complies with ILO, IMO, SOLAS, MARPOL international rules and prioritizes energy efficiency and passenger comfort.

Full Length: 21.57 [m]
 Width: 9.89 [m]
 Depth: 5.487 [m]
 Water Withdrawal: 1,879 [m]
 Away: 148.8 [t]
 Cruising Speed: 12 [knots]
 • Wet Area: 210,684 []
 • 0,578
 • 0,829
 • 0,708

HYCata-Hope engine room consists of 2 decks and 1 bridge. The main deck consists of cabins. There is one master class, two A class and 2 crew cabins on the main deck. The second deck consists of the galley and social living areas.

Tank Capacities

- **Sodium Boron Hydride Fuel Tank Calculations**

HYCata-Hope's hourly energy requirement is 340 kW (320 main machine power + 20 kW power of electrical equipment). 12-hour power requirement is 4080 kW is happening. This includes based on the NaBH₄ fuel tank is calculated as 38 m .

3

- **Waste Water Tank Capacity**

The black water tank capacity is 1200 liters.

- **Gray Water Tank Capacity**

Gray water tank capacity is 1200 liters. The clean water tank is 2200 liters. Tanks
It can accommodate 4 crew + 6 passengers for a minimum of 1 week.

Dispatch System and Components

- **Power supply (Hydrogen and solar panels)**

Using hydrogen from sodium boron hydride in a PEM fuel cell
4080 kW of power generation in 12 hours . At **HYCata-Hope**, the solar panels cover an area of 23 square meters. 440W to power Using solar panels with solar panels, 27.5 kW of energy can be produced daily. This energy other will be used for equipment and the rest will be stored.

- **Fuel cell**

A proton exchange membrane (PEM) fuel cell was selected for use in **HYCata-Hope**. Two 130 kW PEM fuel cells were selected per vessel, totaling 4 PEM fuel cells.

- **Battery System**

For **HYCata-Hope**, there are two batteries on each boat and 4 batteries in total. Each battery is selected to provide 125 kW/h of energy.

- **Electric motor**

For the motor, a 4-pole electric motor producing 160 kW of power was selected.

HYCata-Hope is an innovative zero-emission catamaran powered by Sodium Boron Hydride. Its aim is to reduce emissions, especially carbon emissions, and minimize the effects of global warming within the framework of the Paris Climate Agreement.

Unlike conventional ships, it uses Sodium Boron Hydride as fuel. Sodium Boron Hydride is stored in a tank on board. This ship converts the Hydrogen gas produced as a result of the reaction of Sodium Boron Hydride with water into electrical energy with a fuel cell and provides propulsion by means of an electric motor. After the reaction of Sodium Boron Hydride with water, Sodium Metaborate (NaBO_2) is produced as waste. This component is stored on board for the production of Sodium Boron Hydride again. A Proton Exchange Membrane Fuel Cell was selected for the conversion of hydrogen to electricity in the system. This fuel cell has a high power density.

It is intended to use waste wind turbine blades in the production of HYCata-Hope. The blades of large modern wind turbines consist of 95% glass reinforced plastic material (Dan and Veigh, 2001). Glass reinforced composite materials are preferred because they are lightweight, have high strength and corrosion resistance, and are easy and economical to produce compared to other fiber reinforced plastics (Uysal, 2008). The lifetime of wind turbines is 20-30 years on average (Izmir Development Agency, Accessed July 21, 2023). It is estimated that waste wind turbine blades constitute 10% of fiber reinforced composite material waste in Europe (Eserenerji, 2022).

Mechanical grinding method will be used for the recycling of wind turbine blades made of glass reinforced plastic material. Mechanical grinding is one of the effective methods that can be used for the recycling of glass fiber reinforced wind turbine blades. This method aims to break the wind turbine blades into small pieces and pulverize them. Other methods are pyrolysis, gasification and solvolysis, which are more complex and costly processes. In addition, these processes have not yet reached industrial solutions (Izmir Development Agency, Accessed July 21, 2023). Mechanical grinding is a more suitable and practical option. Glass fiber wind turbine blades subjected to mechanical grinding can be pulverized and then prepared with epoxy, a type of thermoset resin, and reused in composite boat construction. Thermosetting resins are used in many areas such as automotive parts, aircraft components, shipbuilding, wind turbine blades, composite structures and insulation materials. Epoxy is preferred as a resin because it has superior mechanical properties and strength, is more waterproof than polyester, which is also a type of thermoset resin, is less sensitive to temperature and humidity than polyester, and can be used even at temperatures below zero degrees with special hardeners (Republic of Turkey Ministry of National Education, 2016). In addition, suitable parts can be cut from waste wings that have passed the preliminary examination and have sufficient strength and can be used as structural elements such as curtains, beams, decks, etc. in boats.

Innovative ideas include digital twin system, Gate Rudder, Power Management System, Battery Management System, liquid glass application as underwater coating for ships, and utilization of waste wind turbine blades.

5. Address potential technology gaps

- **Recycling of Waste Wind Turbine Blades**

Waste wind turbine blades will be used in the construction of the ship. According to research, wind turbine blade waste is estimated to increase to approximately 2 million tons globally by 2050, and this problem reveals the importance of recycling waste wind turbine blades (Eserenerji, 2022). Thanks to this ship, waste turbine blades will be utilized.

- **Power Management System (PMS)**

Examination of resources, consumption analysis and energy stability an automation system that performs activities and ensures the continuity of the electrical power system

Power Management System (PMS) will be used in **HYCata-Hope** for its benefits in energy efficiency and battery management. PMS prevents unnecessary energy expenditures and optimizes energy according to demand. It also balances loads, helping to use energy resources efficiently and prevent overloading. PMS also enables remote monitoring and control of energy consumption. PMS for batteries prevents overcharging and discharging and increases battery life. In short, PMS ensures the continuity, safety and reliability of the electric power system (EMaC, 2023).

- **Battery Management System (BMS)**

Battery Management System (BMS) will be used to secure and control the battery used in **HYCata-Hope**. The BMS controls and manages the charging and discharging processes of battery packs that are formed by connecting one or more batteries in series or parallel (Daowd, 2011). This system will measure various parameters such as voltage, current, temperature and keep the battery within safe limits. At the same time, BMS can increase battery life and efficiency ((Dubbarry et al., 2013, as cited in Hançar et al., 2021), (Conte, 2006, as cited in Hançar et al., 2021)).

- **Digital Twin**

Digital twin technology aims to create a virtual copy of systems or objects in a digital environment and involves a virtual model that interacts with real-time data. Data taken from the physical environment with sensors is transferred to the virtual environment. In this way, the real environment can be monitored in a digital environment. With digital twin technology, equipment failures can be predicted, the performance of the equipment can be monitored and warnings can be given when necessary (Tao et al., 2018). This technology can predict problems, prevent failure, and plan the future by monitoring, analyzing and simulating data. In this way, inspection costs can be reduced and inspection quality can be increased (Duman, 2022). This system can be used in many areas such as capacity planning, efficient use and optimization of resources, passenger comfort, fault prediction. Currently, digital twins are used as design support in the maritime industry and are used for visualization, analysis and calculation, and various improvements (Semeraro et al., 2021). HYCata-Hope will be equipped with sensors for the digital twin system, which will perform functions such as passenger comfort, performance analysis, fault detection and prevention.

- **Liquid Glass Application**

Liquid glass, i.e. sodium silicate, is a TBT-free substance. Liquid glass; surface It is a transparent, liquid chemical compound used in many areas such as protection, detergents, paper and wood industry, water treatment, construction materials, paint auxiliary, passive fire protection, food and pharmaceutical industry. It is also used to prevent abrasion, create a waterproof surface and provide strength in places such as countertops in homes. Liquid glass forms a protective layer on surfaces, increasing the durability and resistance of surfaces and providing surface protection and resistance to abrasion. At the same time, liquid glass is also used to produce fire-resistant coatings and fire-resistant products in the wood and paper industry (Ataman Chemicalas, 2023). When used in contact with water, it prevents the accumulation of organisms and substances on the surface thanks to its anti-fouling feature, thus reducing the friction of the ship under water. This can save fuel and prevent corrosion. Liquid glass will be applied to the underwater section of HYCata-Hope.

- **Gate Rudder**

HYCata-Hope is designed to provide additional thrust, increase maneuverability, energy and

An innovative rudder system "Gate Rudder™" is used to reduce fuel requirements. Gate rudder provides up to 14% fuel savings. This value can increase up to 30% in extreme weather conditions (Atlar, 2021). The gate rudder can generate additional thrust with the twin rudder fans around it, giving the ship the ability to It can provide a great advantage over conventional rudder in port and pier maneuvers. This reduces energy use, cavitation, vibration and underwater noise levels, resulting in a better navigation (marine bulletin, 2022).

6. Detailed design description

The proposed design idea **HYCata-Hope** is a zero-emission, energy-efficient, green catamaran that promotes the use of renewable resources. In **HYCata-Hope** (HYdrogen Powered Catamaran - **Hope**), it is aimed to send the hydrogen separated as a result of the reaction of NaBH₄ with the help of catalysts to a fuel cell and generate electricity (Shakeri et al., 2020). A proton exchange membrane (PEM) fuel cell was selected for this system. The reasons for choosing this fuel cell are that the operating temperature is at a suitable value of approximately 80 degrees (Öztürk, 2010) and the power density is at a high rate of 350 mW/cm². With features such as high power density and variable power output, proton exchange membrane fuel cells have the potential to be used in transportation vehicles.

7. Stability

Intact State

Drafts at equilibrium angle

Draft at AP	1.881	metres
Draft at FP	1.877	metres
Mean draft at midships	1.879	metres

Hydrostatics at equilibrium angle

Density of water	1.0250	tonnes/cu.m
Heel	No heel	
Trim by the stern	0.003	metres
KG	3.787	metres
FSC	0.048	metres
KGf	3.835	metres
GMt	5.244	metres
BMt	8.065	metres
BMI	20.285	metres
Waterplane area	91.87	sq.metres
LCG	9.582	metres
LCB	9.582	metres
TCB	-0.000	metres
LCF	9.414	metres
TCF	0.000	metres
TPC	0.942	tonnes/cm
MTC	1.400	tonnes-m/cm

Righting Lever (GZ) Curve

Heel to Stbd (deg)	GZ (m)	Crowding (m)	Turning (m)
0.00	-0.0000	0.0332	0.1202
5.00	0.4581	0.0332	0.1202
10.00	0.9146	0.0332	0.1202
15.00	1.3754	0.0332	0.1202
20.00	1.8295	0.0332	0.1202
25.00	2.1964	0.0332	0.1202
30.00	2.1232	0.0332	0.1202
35.00	1.8371	0.0332	0.1202
40.00	1.5390	0.0332	0.1202
45.00	1.2353	0.0332	0.1202
50.00	0.9318	0.0332	0.1202
55.00	0.6357	0.0332	0.1202
60.00	0.3500	0.0332	0.1202

IMO Turning

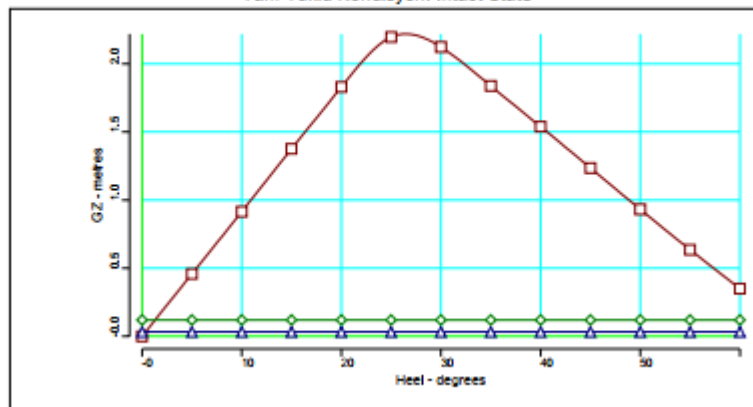
Property	Value	Units
Area A	1.21182	m-radians
Total Area A+B	1.33628	m-radians
Steady state angle	1.311	degrees
Max. angle	60.000	degrees

IMO Passenger crowding

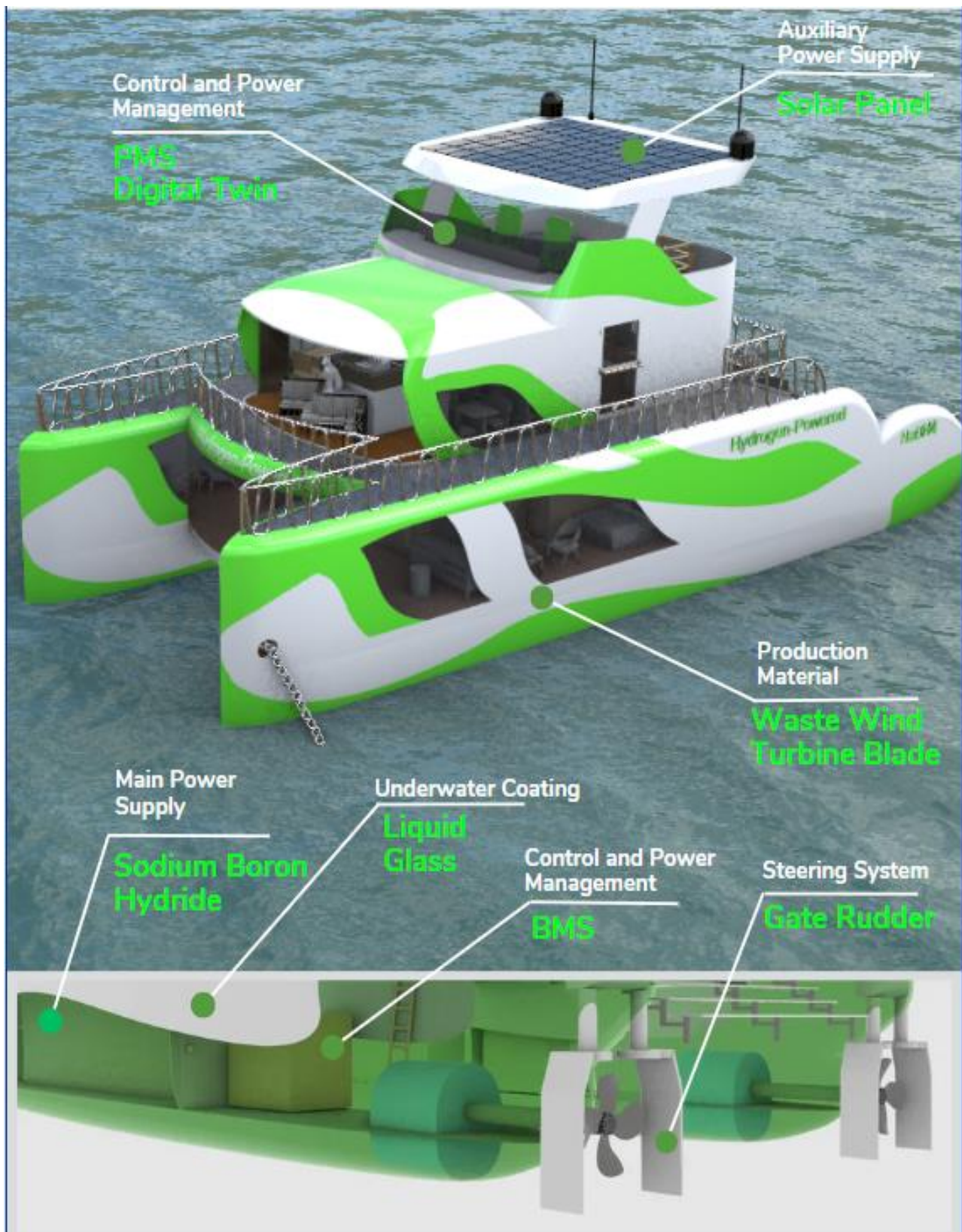
Property	Value	Units
Area A	1.30158	m-radians
Total Area A+B	1.33628	m-radians
Steady state angle	0.363	degrees
Max. angle	60.000	degrees

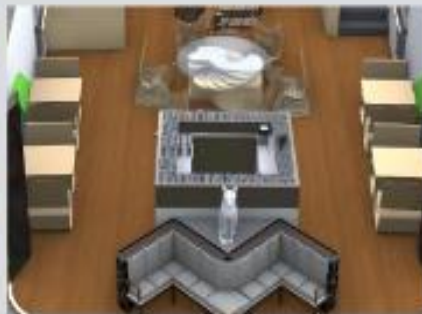
Intact State

Tam Yüklü Kondisyon: Intact State

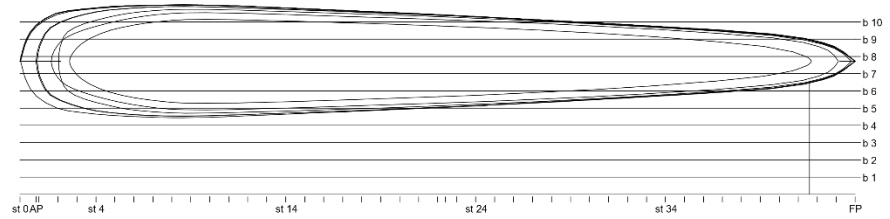
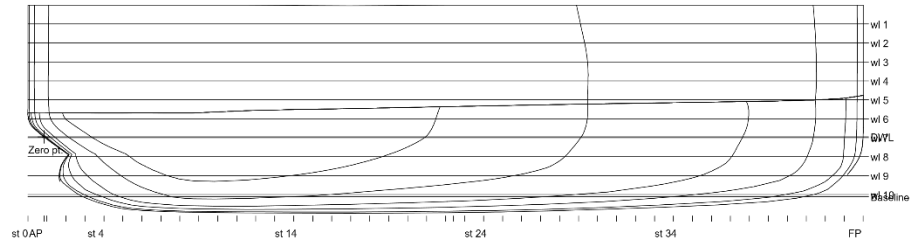
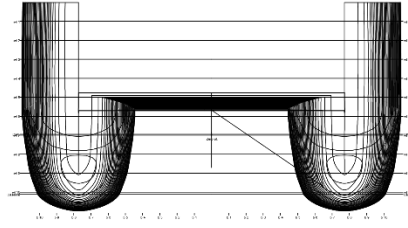


8. Source of additional information used & Appendices

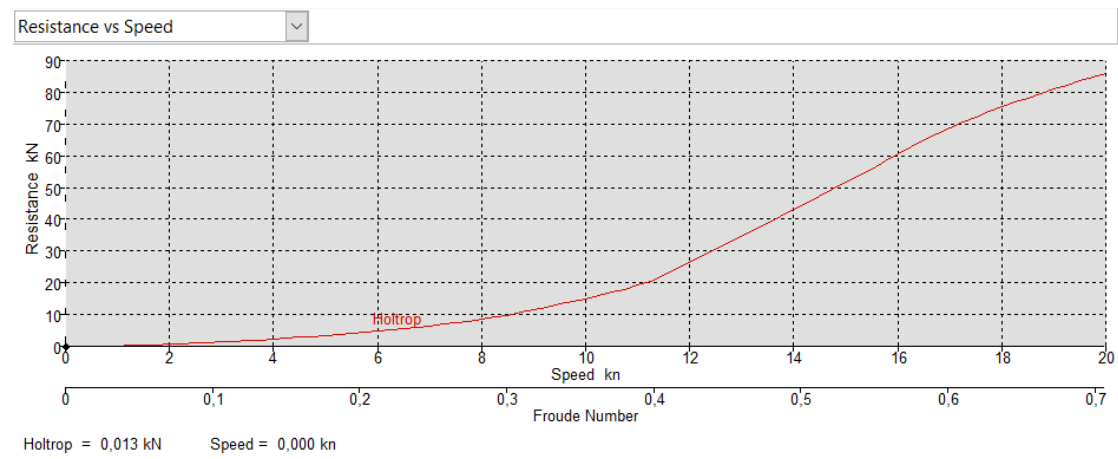
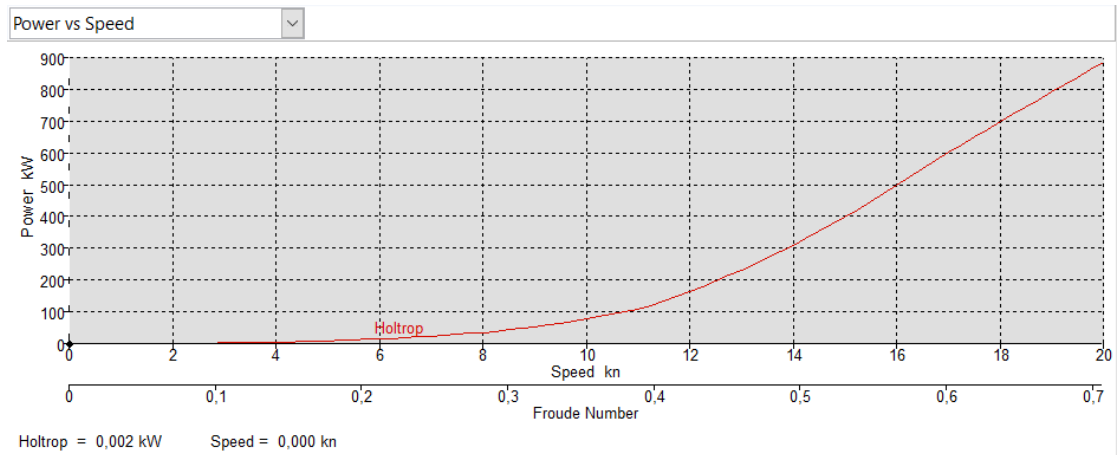




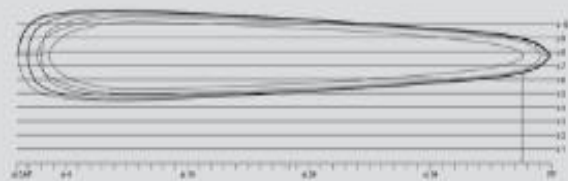
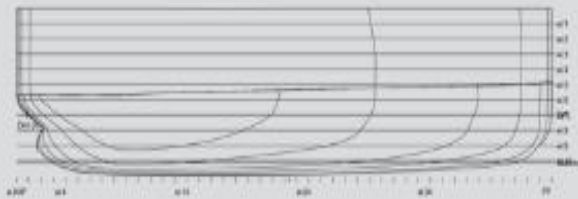
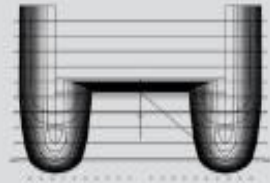
Endaze Planı



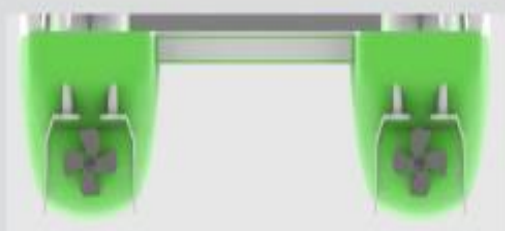
Kategori:	26 Metre Altı Katamaran Gözintili Teknesi
Geminin Adı:	HYCata Hope
Ölçek:	A3
Tam Boy:	21,57[m]
Genişlik:	9,89[m]
Derinlik:	5,487[m]
Su Çekimi:	1,879[m]
Cb:	0,576
Deplasman Tonaı:	148,8[t]



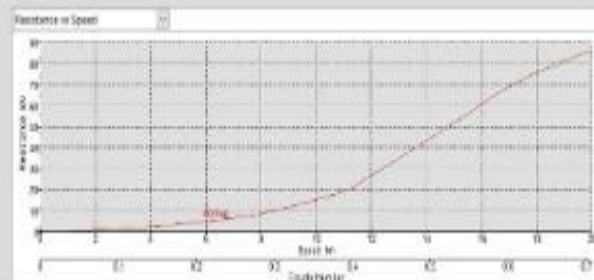
Sheer Draught



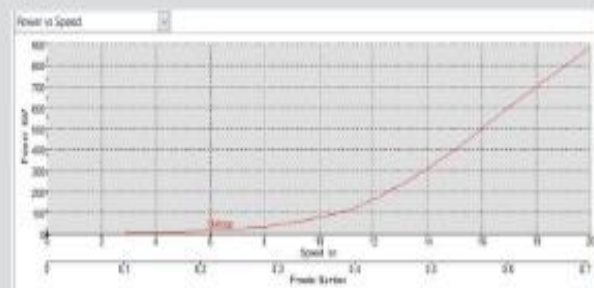
Form Design



Gate Rudder Resistance - Speed Graph



Gate Rudder Power - Speed Graph



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