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The Importance of an Unmanned Surface Vehicle: A Point of View

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Abstract

In the world there are various types of unmanned vehicles: Unmanned ground vehicle, unmanned aerial vehicle, unmanned surface vehicle and unmanned underwater vehicle. The objective of this paper, however, is to present the importance of an unmanned surface vehicle (USV) in the Black Sea. The safe operations of all USVs are carried out by experienced and qualified operators. These operators can control a USV from a ship or from land. An USV is equipped with various devices (eg. video camera, long range antennae or autopilot box) depending on the mission it has to carry out at sea. These boats are launched through launch and recovery system (LARS). Furthermore, the USVs do not pollute and do not make noise during their activity on sea. Finally, it is expected that the unmanned surface vehicles will further develop, depending on new requirements present in the Black Sea.

1. Introduction

An unmanned vehicle is under remote human control either radio-controlled or automatically guided by a GNSS-based application. Moreover, there are many types of unmanned vehicles such as: Unmanned ground vehicle (UGV), unmanned aerial vehicle (UAV), unmanned surface vehicle (USV) or unmanned underwater vehicle (UUV), as shown in Fig 1.
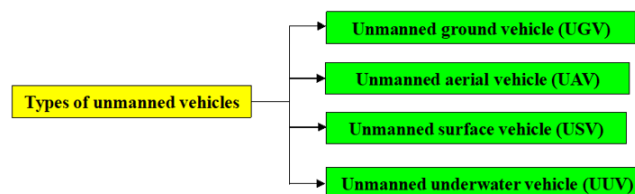

Fig 1: Types of unmanned vehicles

The unmanned surface vehicles can be launched on the sea with the help of LARS (Launch and recovery system). This system allows for the safe capture and release of USVs without requiring human action [1].
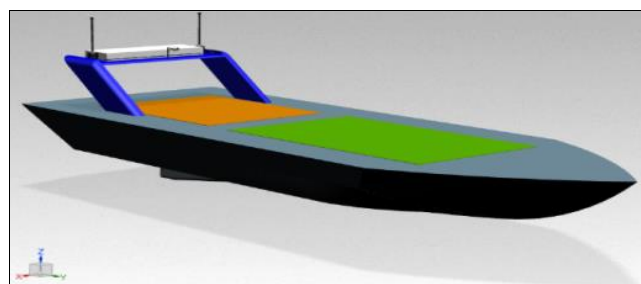

Fig 2: 3D model → USV

In this manuscript, we designed a 3D model of an unmanned surface vehicle (USV), as presented in Fig 2.

The dimensions of a USV depend on the area in which it is used: Lake, sea or ocean [2].

Table 1: Parameters of a USV

Parameters	Dimension (m)
Length overall (LOA)	2.57
Waterline length (LWL)	2.37
Breadth	0.8
Depth	0.2
Draft	0.12

Table 1 shows above the parameters of an unmanned surface vehicle (USV) used in the Black Sea.

2. Study of an unmanned surface vehicle

Usually, USVs are used in almost all seas. Meanwhile, the Black Sea is famous for its violent and sudden storms and in this case it is desired to use these boat [3].

In the Black Sea, the USVs are often a better alternative to traditional manned boats in several critical situations such as:

➢ In high-risk maritime missions where the safety of the crew is substantial.
➢ It is not profitable to use a boat with crew.
➢ In rough sea conditions, where the well-being or comfort of the crew may be compromised.

Anyway, depending on the missions that USVs have to perform on the Black Sea, they are equipped with different special devices [4].

The main features of an AUV are: Compartment for sensors, battery and engine compartment, autopilot box, video camera and long-range antennae, as shown in Fig 3 below.
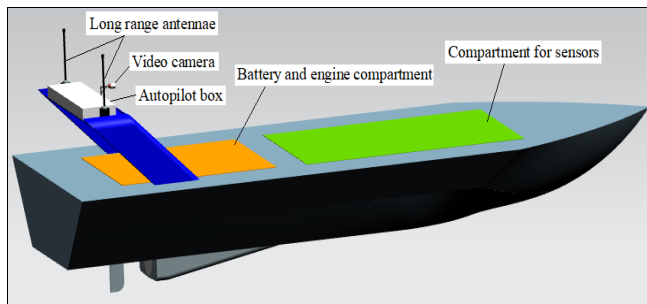

Fig 3: Main endowments → USV

During its activity, an unmanned surface vehicle mainly uses three modules: A drive module (ex. propeller), a navigation module (ex. autopilot box) and a communication module (ex. long range antennae), as in Fig 4.
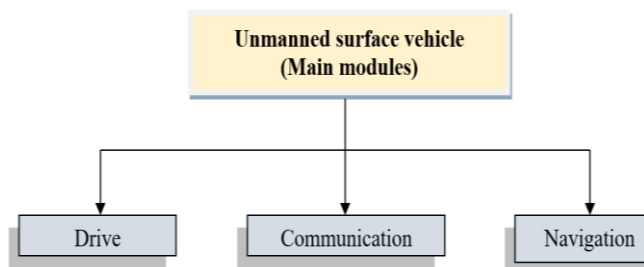

Fig 4: Main modules → USV

Usually, an USV is constructed from fiberglass and offers marine solutions for military and commercial applications [5]:

a) Military applications: Anti-submarine warfare (detection and attack), anti-piracy patrol, early warning, unmanned remote weapon, maritime border security or assist in laser guided tasks, detection against undersea mines.

b) Commercial applications: Surveillance of harbor, patrolling of maritime border, environmental remote sensitivity, protection of underwater pipelines, oil spill mitigation and hazardous material detection.

Digital wind tunnel simulation, also known as computational fluid dynamics (CFD) simulation, offers a number of advantages over conventional wind tunnel experiments for the study of a USV.
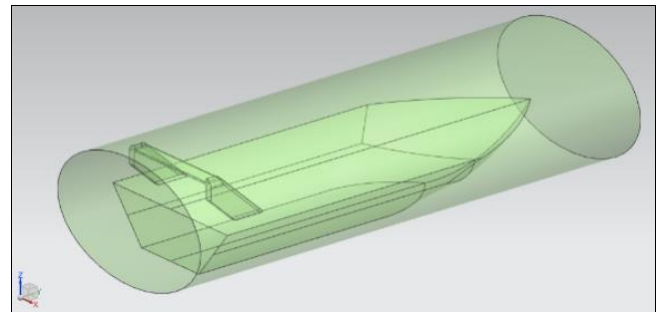

Fig 5: USV into wind tunnel for CFD

Digital wind tunnel simulations for USVs are faster, have good precision, they are more efficient, more accurate and more environmentally friendly than conventional experiments, as it may be seen in Fig 5 above.

We performed a CFD (Computational fluid dynamics) study to analyze the air flow from the bow of an unmanned surface vessel, as it is presented in Fig 6 below.
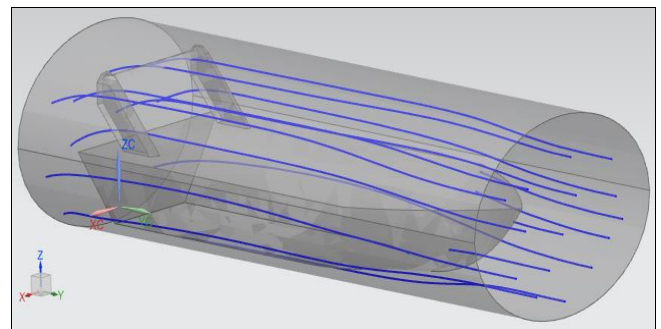

Fig 6: Air flow on the USV

In the study of an ATV in a digital wind tunnel, at least two methods are used: The finite volume method (FVM) and a weighted residual [6].

In the Finite Volume Method (FVM) the relation below is used:

$$\frac{\partial}{\partial t} \iiint Q dV + \iint F dA = 0 \qquad (1)$$

Where:
▪ Q - Vector of conserved variables.
▪ F - Vector of fluxes.

- dV - Volume element.
- dA - Area element.

In the Finite Difference Method (FDM) the formula below is used:

$$\frac{\partial Q}{\partial t} + \frac{\partial G}{\partial x} + \frac{\partial H}{\partial y} + \frac{\partial I}{\partial z} = 0 \tag{2}$$

Where:
- G, H, I - Fluxes.
- x, y, z - Directions.
- t - Time.

In the digital wind tunnel simulations, the air currents that act on a USV have different values, as in Fig 7.
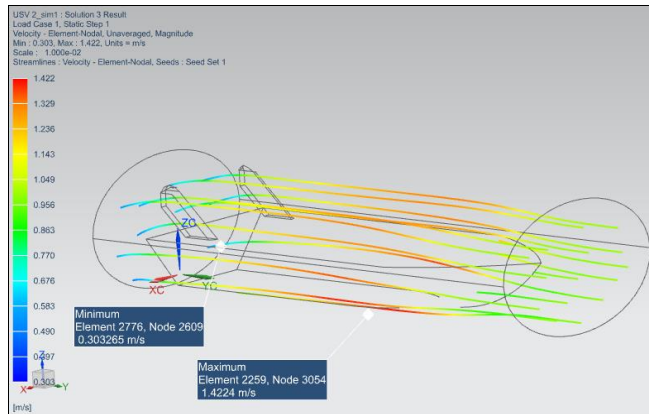

Fig 7: Nodal velocities → USV

Table 2, shows the extreme values of the nodal velocities from finite elements on the unmanned surface vehicle.

Table 2: Nodes ans elements → USV

No.	Node	Element	Values (m/s)	Observation
1	2609	2776	0.303265	Minimum value
2	3054	2259	1.4224	Maximum value

During the analysis, the air currents in the tunnel exert different pressures on the USV, as in Fig 8 below.
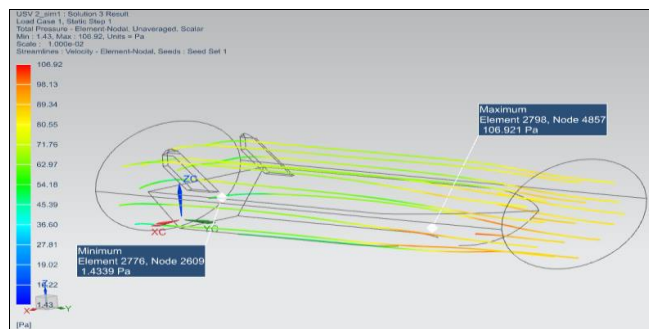

Fig 8: Total pressure → USV

Table 3, shows the extreme values of the total pressure from finite elements on the unmanned surface vehicle.

Table 3: Total pressure → USV

No.	Node	Element	Values (Pa)	Observation
1	2609	2776	1.4339	Minimum value
2	4857	2798	106.921	Maximum value

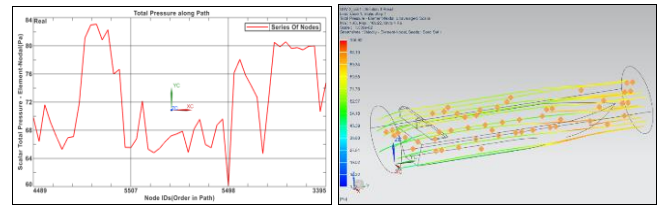The total pressure values are positive in the diagram below.

Fig 9: Diagram of total pressure → USV

In fact, the total pressures range from 60 Pa to 84 Pa, as shown in Fig 9 above.

3. Conclusions

With technological advance, the unmanned surface vehicles (USVs) have been used in increasingly complex missions. Some complex missions that can be performed in the Black Sea are:
- Identification of people at sea in bad weather.
- Identification of sea mines in harbor.
- Defense of the coastline in case of need.
- Collection of marine meteorological data in harsh environments.

In this paper, we explored several advantages of using USVs on the Black Sea:
- Disturbing factors such as wind, turbulence and other atmospheric conditions have less impact on the stability of USVs.
- Data transmission is fast.
- Ability to operate for long periods on the sea.
- Unlike UAVs, USVs do not require specific take-off and landing spaces. Hence, the mode of operation is more flexible.
- The USVs generally have a limited payload capacity, so that they can carry sophisticated equipment, (eg. multiple beam sonar systems).

As technology continues to advance, USVs developments present a promising future for underwater exploration and mapping in the Black Sea.

4. Acknowledgement

5. References

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