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The underwater glider: An economic approach

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ABSTRACT

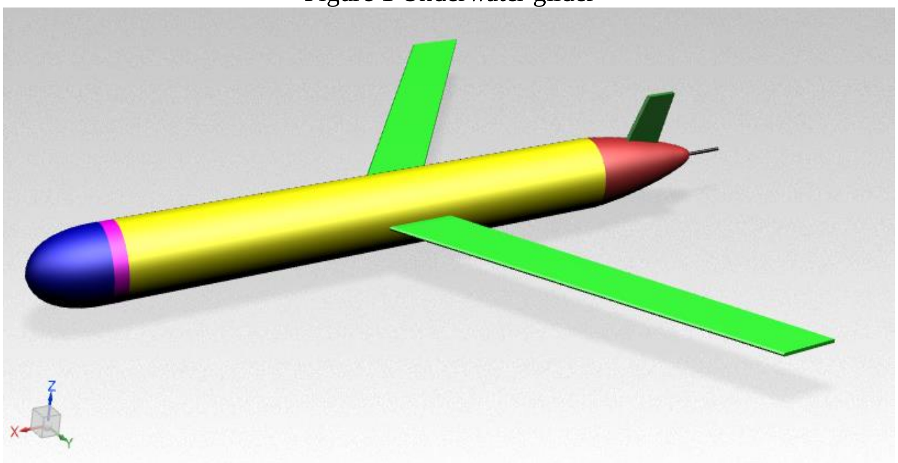
The article presents aspects about the economic importance of the underwater glider. For this purpose, we designed in 3D an underwater glider. In this case, the underwater gliders use their wings to glide along in the Black Sea, because Black Sea is a marginal Mediterranean Sea lying between Asia in Europe. The Black Sea has a maximum depth of 2212 m. In this manuscript, we have briefly presented the areas of activity for underwater gliders. Underwater gliders use very little energy because they do not have any motors and propellers. These autonomous underwater vehicles, can dive as deep as 1000 m. Another interesting thing is that the underwater glider can go at a speed of up to 0.15 m/s in vertical motion. But if the currents help them along, these underwater gliders can reach a speed of up to 0.27 m/s.

KEYWORDS: buoyancy, wing, researcher, ascending, diving.

1. INTRODUCTION

The first underwater glider was put into operation for the first time in the early 1960s and was called Concept Whisper. As evident from Fig. 1 below, the underwater gliders have developed at least from a constructive point of view.

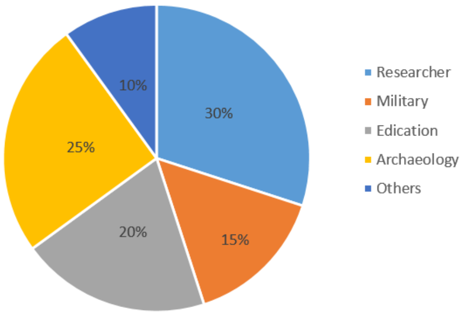
Figure 1 Underwater glider



Source: own processing, 2024

An autonomous underwater vehicle (AUV) uses in generally propellers or traditional thrusters as a means of propulsion. Nevertheless, the underwater glider is an autonomous underwater vehicle, (Panaitescu et al., 2015). Underwater gliders use as propulsion only a system with variable buoyancy in the water. A newer model of underwater glider is a hybrid, which is designed to travel as follows: sliding mode, under power, or both ways.
Underwater gliders are used in several important fields: researcher (biology, weather, etc.), military, education, archaeology and others, as shown in Fig. 2.

Figure 2 Areas of activity for underwater gliders



Source: own processing, 2024

In addition, new areas of activity of underwater gliders are: environment and pisciculture (Nutu, 2012)

2. EFFICIENCY OF UNDERWATER GLIDERS

An underwater glider is a small autonomous submarine. This means that it is unmanned, because no one could fit therein. Usually, these underwater gliders are only about two meters long and weight about fifty kilograms. Table 1 shows principal characteristics of the underwater glider, (Nastasescu, 2022).

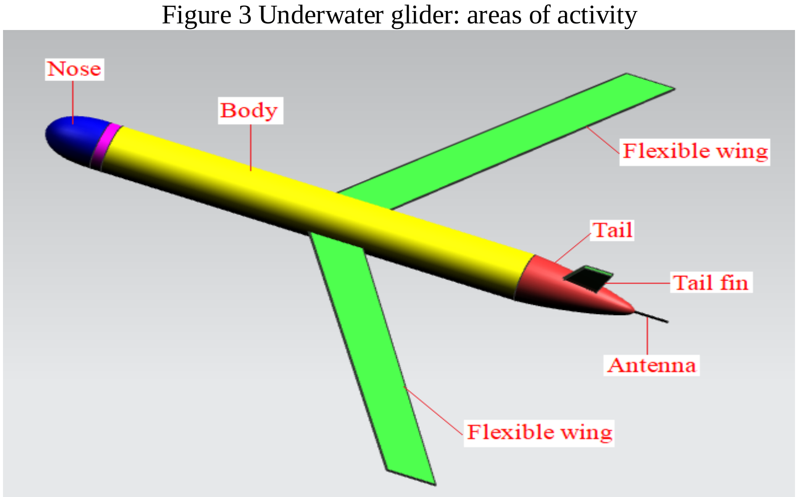
Table 1 Principal characteristics of the underwater glider

No.	Characteristics	Value
1	Length, L	2 m
2	Body diameter, d	0.25 m
3	Wing length, W_L	0.45 m
4	Wing width, W_W	0.15 m
5	Tail fin length, R_L	0.24 m
6	Tail fin width, R_W	0.12 m
7	Weight, m	50 kg

Source: own processing, 2024

As we can see from the Fig. 2, the fundamental components of the underwater gliders are: nose, body, tail, tail fin, flexible wings and antenna.

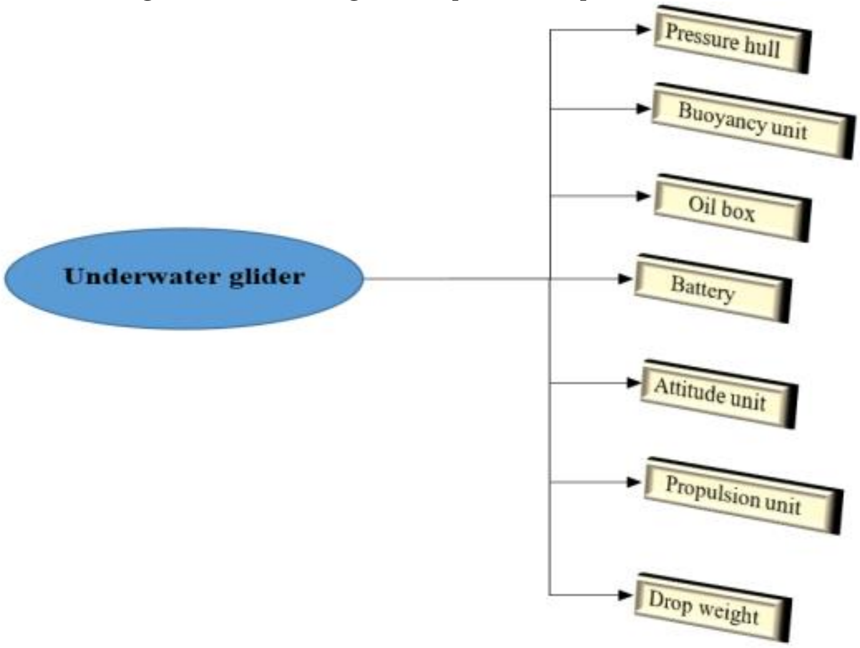
Figure 3 Underwater glider: areas of activity



Source: own processing, 2024

On the other hand, the important components inside the underwater glider are: pressure hull, buoyancy unit, oil box, battery, attitude unit, propulsion unit and drop weight, as shown in Fig. 4.

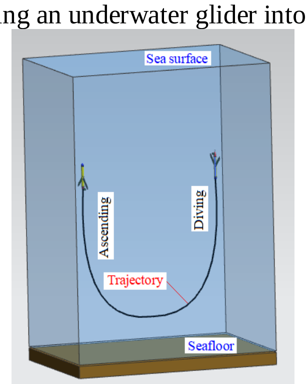
Figure 4 Underwater glider: important components inside



Source: own processing, 2024

The underwater gliders are driven by changes in buoyancy. Namely, they are controlled by pumping oil in and out of an external bladder or using a piston. Therefore, this autonomous underwater vehicle has a vertical movement in the water column between sea surface and specified depth (until seafloor).

Figure 5 Moving an underwater glider into the Black Sea



Source: own processing, 2024

As we can see from the Fig. 5, the underwater glider has a diving (downward tilt) and an ascending (upward tilt) motion.

In the study of the underwater gliders launches into the sea, we can use Bayes theory. Because, Bayes theorem is a method of determining conditional probabilities, (Raicu, 2012).
Thus, Bayes Theorem is mathematically formulated as the following equation below:

$$P(A/B) = \frac{P(B/A) \cdot P(A)}{P(B)} \quad (1)$$

Where:

- A, B are events.
- P(B/A) → Likelihood: the probability of B given A.
- P(A) → Prior: the probability of A occurring.
- P(B) → Marginalization: the probability of B occurring.
- P(A/B) → Posterior: the probability of A Given B.

In order to study the launching of an underwater glider in the Black Sea, we use Bayes Theorem and the Douglas sea scale. The Douglas sea scale is a scale which measures the height of the waves and also measures the swell of the sea, (Belev, 2019).
According to the weather, the value of the Black Sea, can be: calm, moderate or rough, as in Fig. 6.

Figure 6 Satelitte → Black Sea map

Source: Nasa Earth Observatory, 2022

In this paper, for the purpose of launching of an underwater glider, we analyze three types of Black Sea waves according to the Douglass scale, as in Table 2.

Table 2 Douglass scale for launching an underwater glider

Code	Waves	Name
	m	
1	0.00	Calm
2	1.30	Moderate
3	3.50	Rough

Source: own processing, 2024

We presented below the situation of launching of an underwater glider depending on the waves in the Black Sea, as in Table 3.

Table 3 Launching an underwater glider → Dataset

No	Outlook	Launch
1	Rough	No
2	Rough	No
3	Moderate	Yes
4	Calm	Yes
5	Calm	Yes
6	Calm	No
7	Moderate	Yes
8	Rough	No
9	Rough	Yes
10	Calm	Yes
11	Rough	Yes
12	Moderate	Yes
13	Moderate	Yes
14	Calm	No

Source: own processing, 2024

Frequency table for above dataset is as below, as we can see from the Table 4.

Table 4 Launching an underwater glider → Frequency table

Frequency table		
Outlook	**Yes**	**No**
Calm	3	2
Rough	2	3
Moderate	4	0

Source: own processing, 2024

For the above Frequency table results, Likelihood table is as below, as in Table 5.

Table 5 Launching an underwater glider → Likelihood table

Likelihood table				
Outlook	**Yes**	**No**		
Calm	3	2	5/14	0.36
Rough	2	3	5/14	0.36
Moderate	4	0	4/14	0.28
	9/14	5/14		
	0.64	0.36		

Source: own processing, 2024

P (Calm/Yes) = 3/9=0.33
P(Calm) = 5/14=0.36
P(Yes) = 9/14=0.64

Likelihood of "Yes" given Outlook "Calm" is:

$$P(Yes/Calm) = \frac{P(Calm/Yes) \cdot P(Yes)}{P(Calm)} \quad (2)$$

$$P(Yes/Calm) = \frac{0.33 \cdot 0.64}{0.36} = 0.59$$

3. CONCLUSION

Nowadays, the underwater gliders production has increased a lot due to the advantages of these underwater vehicles. These advantages are:

- They can work 24 hours a day and 7 days a week.
- They can cover large distances.
- They can go long-term missions.
- They are autonomous unmanned systems (AUV), so there is no need for humans inside. Therefore, they are much cheaper.
- Some underwater gliders can include many different sensors to measure all sorts of data (salinity, temperature, chlorophyll, oxygen, sounds, etc.).
- They do not make noise during the mission.

Even though, the underwater gliders move very slowly, they allow to gather almost real-time data.
Moreover, due to their durability and versatility, underwater gliders, they perform well in the Black Sea, when they are operating in a fleet, as a mobile network of re-configurable sensors.

4. ACKNOWLEDGEMENTS

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