OMER

Final design report Omer 8

Table of contents

Table of illustrations

Table of tables

Introduction

Since the beginning of the 1990s, the OMER Submarine Club members manifested their will to raise the standards of the International Submarine Race (ISR). Up till now, the OMER Club has held the speed record in all four categories.

Table 1 - Last speed world records by OMER submarines

SUBMARINES	CATEGORY	YEAR	SPEED (Knots)
OMER 4	One person, propeller	2001	7.192
OMER 5	Two person, propeller	2007	8.035
OMER 6	One person, non-propeller	2007	4.916
Omer 7	Two persons, non-propeller	2009	5.133

After having made these 4 records, our team wants took up the challenge of beating our previous record set by Omer 4 with our new prototype Omer 8. With the experience acquired in the fabrication of Omer 6 and Omer 7, the team has improved it`s abilities for designing hull and mechanical systems. The team Omer developed new techniques of fabrication that make better quality pieces.

Omer 8 has a number of improvements that push the limits of a fast and stable submarine. In this document we will review in detail the hull, the propulsion system, the fins, the direction system and the security system.

The team is currently putting in many hours of hard work in order to finish the fabrication and testing of the new prototype.

1.Presentation of the submarine

1.1. *General characteristics*

Omer 8 is a one person submarine with propeller. We decided to come back to using a propeller system, because with the years we accumulate a lot of experience with dimensioning of the hull and propeller. We decide that using the knowledge we developed with Omer 6 and 7 would give us the best chances to reach our goal which is to beat the record set by Omer 4 in 2001. This year, we did all the modeling and designing of all the submarine parts in 3 dimension using CATIA V5R19. We shall now present the main components of Omer8

The hull

It`s hull is the smallest in volume we have ever made with a length of about 105 inches and a diameter going up to 24 inches. The design which is made with NACA airfoils and ellipses will be explained in more detail in the section 2.

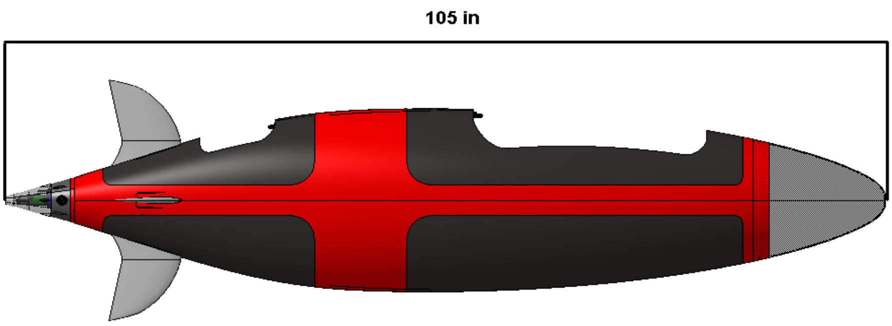


Figure 1- Submarine's Length

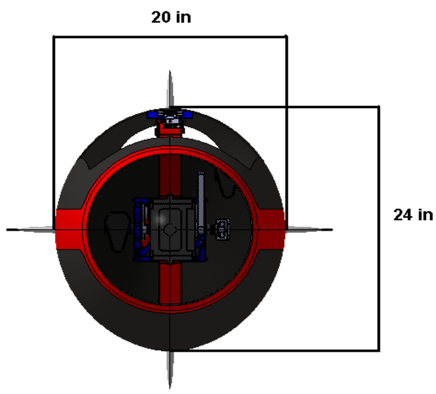


Figure 2- Submarine's diameters

The Propulsion

The submarine`s propulsion system has a similar design to Omer 4. The system consists of transferring the power of pedaling to a rotor installed at rear of the submarine. We used the same design for the gear box but we added a variable pitch control in the rotor. The variable pitch control varies the angle of the propeller in order to have more effective propulsion. The control of the angles is done electronically. More details on the propulsion system are in section 3.

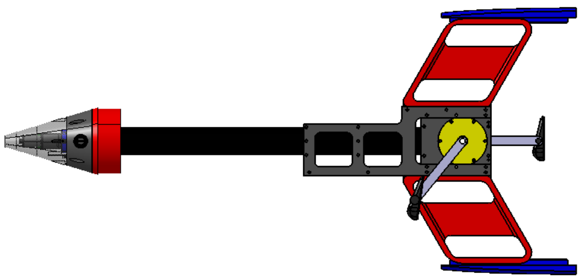


Figure 3- Assembly of the propulsion system

The Direction

The submarine is directed by four fins that are positioned at the rear of submarine. These fins are controlled by a fully mechanical system composed of a joystick and a gear box. The link with the joystick and the gear box is made with stainless steel cables. So, the direction is made of cables that move linearly due to the joystick and generate a rotation movement in the gearbox. More details about the direction are in section 6.

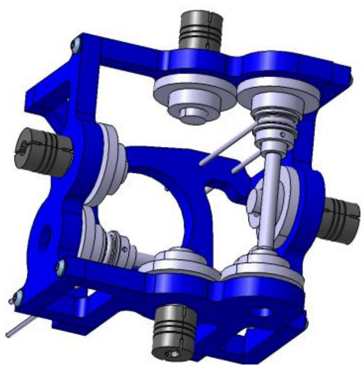


Figure 5- Direction's gearbox

Figure 4- Direction's joystick

The security system

Since the security system used in Omer7 was very effective, we decided to use the same one for our new prototype. The system is a pneumatic circuit with actuators and switches that control the opening of the door and the release of the pop-up buoy. The system has a switch to only open the door and the pilots also holds a switch that opens the door and releases the pop-up buoy if the pilot releases it. More details on this system are in section 6.

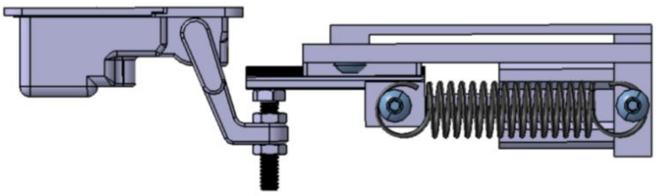


Figure 6-Door release mechanism

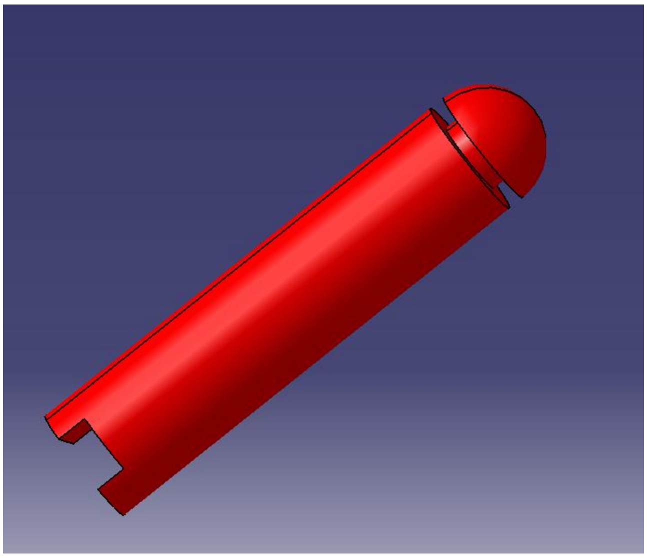


Figure 7-Deadman switch

2. Hull

2.1. *Constraint*

We first had to evaluate the minimum required space to be able to pedal using or gear system. In order to acquire these measurements, we used a mannequin which had the same dimensions as our destined pilot positioned in a pedaling position. As you can see in the image below, we positioned the knee in 90 degree to evaluate the worst case in pedaling. The other thing is the position of the feet. With the propulsion system and the feet width it is another limit to dimension the hull. After that, we have the shoulders width that is important to be considered. Finally, the position of the head that represent the length taken by the mannequin limits the length of the hull. In the table below, there is the dimension of the constraints.

Table 2- Dimension of the constraints

hip length	19 in
Feet width	16 in
Shoulder width	19 in
Total length	70 in

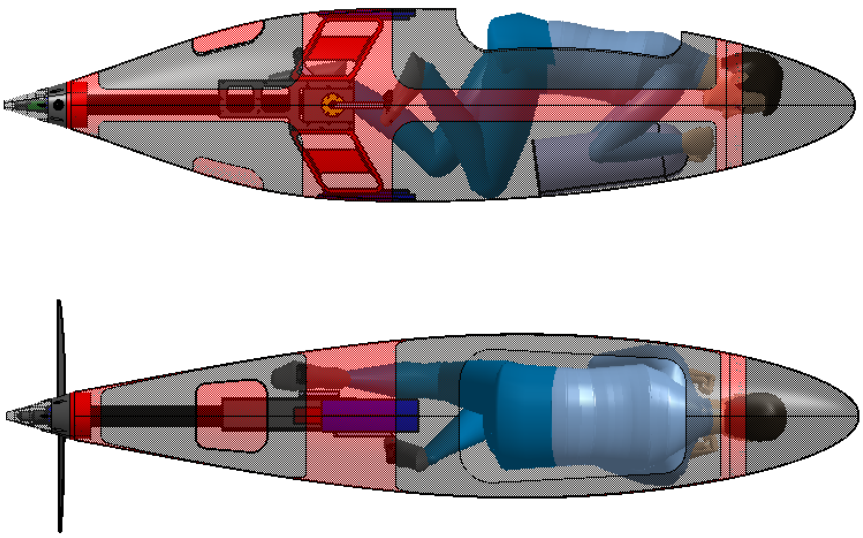


Figure 8- Mannequin fitting

2.2. ***Methodology***

After having found all the constraints, we begin to choose the rights airfoils that fit with the mannequin and decide to use NACA series 6 airfoils. We then decided to use the same technique used with Omer 7 to do the modeling the hull. The technique consists of having an airfoil in a horizontal plane and an airfoil in the vertical plane. To links those airfoils we used ellipses that separate the submarine in four. With the ellipses and airfoil we can generate a surface in our software. In order to have a perfectly symmetric hull we modeled only a quarter of hull and we use a symmetry operation to make the complete hull.

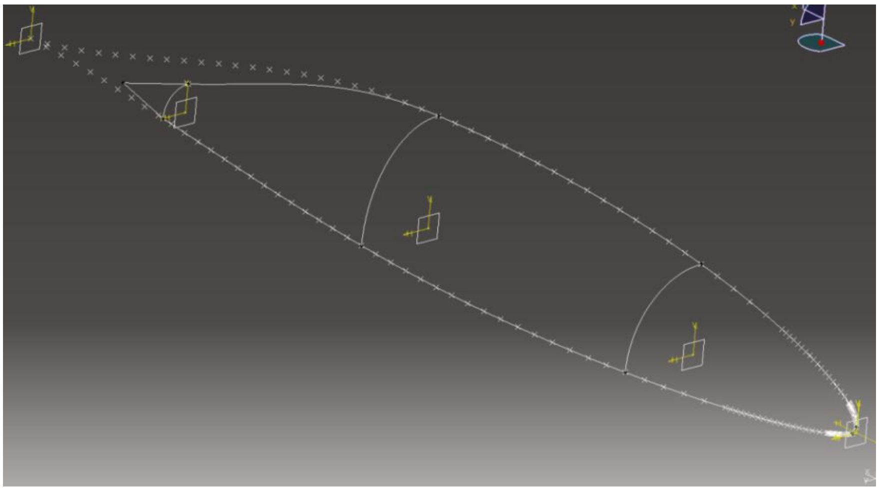


Figure 9- Hull modeling in Catia software

To choose the vertical airfoil we take the hip length and the minimum length needed for the hull. For the horizontal airfoils is dimensioned in function of the shoulder width and the feet width. The airfoils used are formed in function of the chord length. In the NACA series 6, we chose the airfoil by the maximum width (depending on the chord length) and the position of this maximum width. In this case, we choose a maximum width near the front of the hull to place the shoulders and a maximum height further back for the hip length.

2.3. ***Ergonomic test***

After we modulated some tests hulls, we analyzed if there's enough space to pedal with all the parts like the tank, the propulsion system and the direction system. As shown in the images below, our analysis was done section by section to see if there is any contact with the hull.

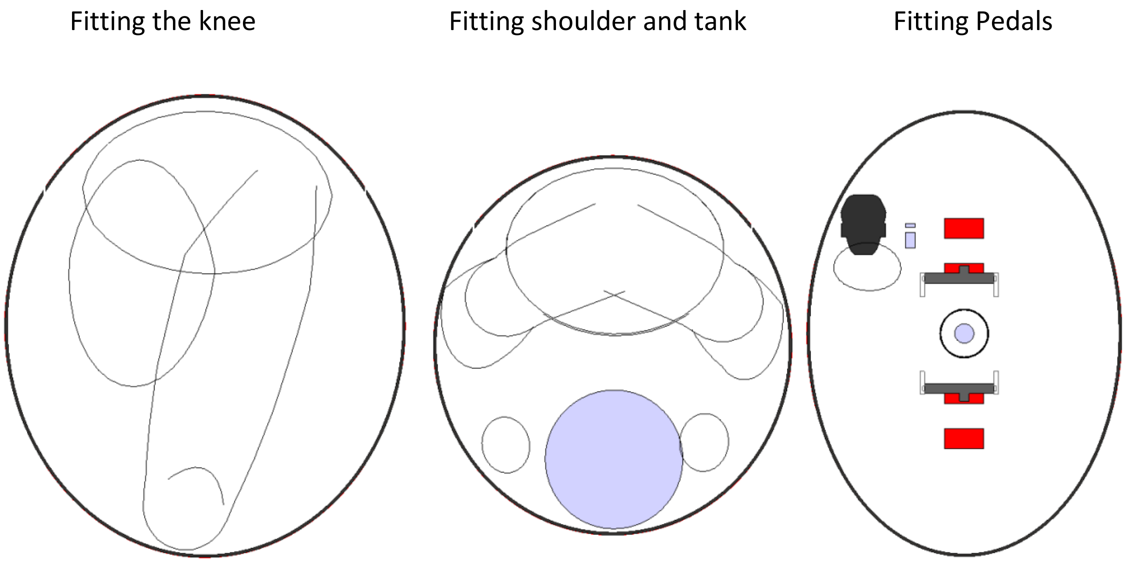


Figure 10- Section view of the submarine

After having fitted the knees and the shoulders, we identified the position of the pedal and the foot when pedaling. For that, we did some test with Omer 4 in a basin to see if the heel has to be higher than the pedal axel when the pedal board passes in the top section of the hull and concluded that the pilot can pedal with the sole of his shoes flat against the pedal board.

2.4. *Hydrodynamic analysis*

After we fitted the hull prototypes with the mannequin, we tested them with CFD (computational fluid dynamics) software to choose which has less drag. The software is called Cosmo Floworks made by Solid works 2007 and permits us to simulate a fluid (water) with a speed of 4m /s that goes through the hull and thus runs a simulation that gives the trajectory of the fluid and the force of drag in Newton. Our selection of the hall is based on the hull that has the least drag.

To obtain optimal results we simulate and compared with the hulls of our previous submarines (Omer 3, 6 and 7). Since Omer 3 was the smallest of the hulls, we decided that it`s drag level was the one to beat. We wanted to simulate the hull of Omer 4 but we couldn't find it`s 3D model.

2.1. *Fabrication*

The process used to fabricate the shell of the new prototype of one person propelled submarine is called resin infusion process. This technique has been selected because it does not require any expensive tools, it allows us to obtain a good surface finish and, most importantly, because the molding of the shell can be done in one operation (fiber + foam core). This process allows us to save money and time and to obtain the best mechanical properties possible of the sandwich construction.

Here's a representation of the infusion process with the required material:

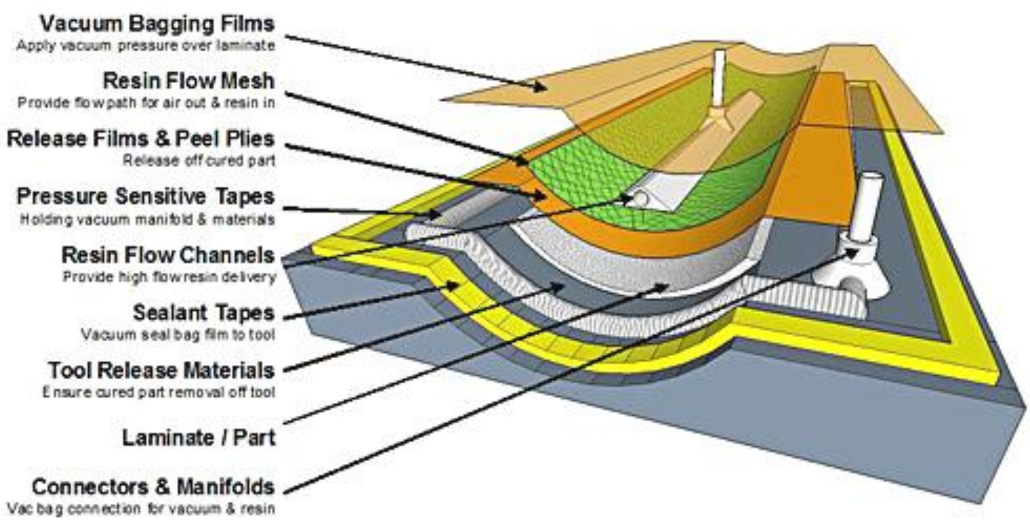


Figure 11- Infusion molding setup

Just like its predecessor Omer7, our new prototype uses a combination of carbon fiber and epoxy resin. There is a slight difference in the outer layer of our prototype; it's a combination of carbon fiber and innegra fiber. This fiber has been developed to have a better impact resistance than carbon fiber only and it gives a nice look to the shell.

Here's a representation of the carbon/innegra fiber:

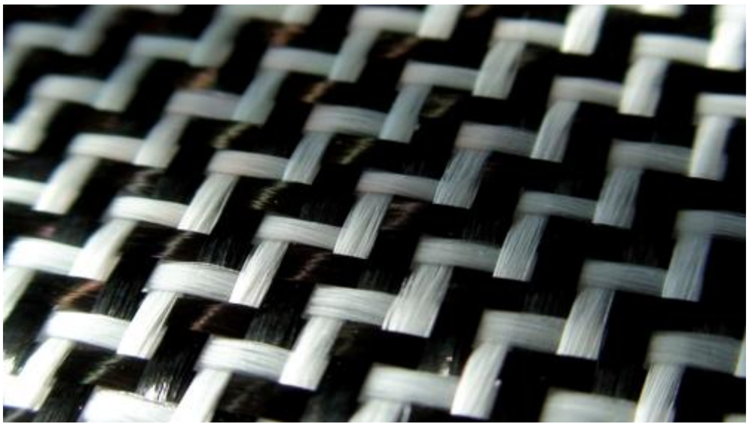


Figure 12- Carbon fiber used for the hull

The window of the nose of the submarine is made of polycarbonate (Lexan) which gives a good impact resistance and is completely translucent. The window is thermoformed using a combination of high temperature and vacuum process in a radiant panel oven.

Here's a representation of the mold used for the thermoforming process:

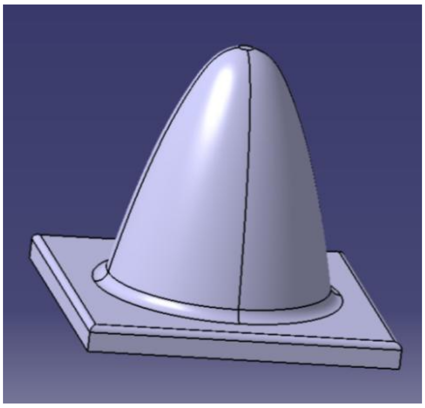


Figure 13-front window mold

2.2. ***Final hull***

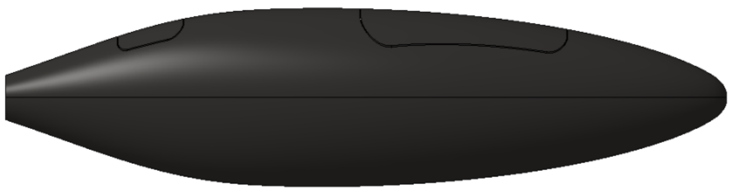


Figure 14- Final hull shape

The selected airfoils are the NACA66020 for the vertical plane and the NACA63013 for the horizontal plane. With these two airfoils we obtained the smallest hull possible that will fit the mannequin. With this hull we were able to obtain the lowest drag of all our submarines with a drag of 53.7 Newton. The surface area is close to 4 square meters and the length of the hull is 105 inches. With all the work we put into the choice and fabrication of this hull, we truly believe that it will be fastest and most stable of our submarines. In order to do a small comparison of the improvements, here is a table with the specifications of Omer 8, 7 and 3.

Table 3- Hull's specifications of OMER 8, 7 and 3

	Omer 8	Omer 7	Omer 3
Volume (m3)	0.392	-	0.4
Surface Area (m2)	3.997	7.712	3.656
Length (in)	105	193	107
Estimated Drag (N at 4 m/s)	53.7	161	76
Biggest diameter (in)	24	29.3	24.8

3. Propulsion

The propulsion system is designed to transfer the power of one person pedaling to the propeller. Thus, we decided to use the same system as Omer 4 for the gear box which readjusts the rotation of a pedal board to a propeller. This choice was made considering that the gear box of Omer 4 was optimal and a new design would be a waste of effort. Nonetheless, we designed a new propeller and the variable pitch of the new propeller. By doing so, we think that we can optimize their functioning compared to Omer 3 and 4 (1-person submarine with propeller). In the next section, we will explain the functioning of the propulsion system and all of its components.

3.1. ***Propulsion system modeling***

The first thing that we did, before modeling in 3D, was to draw on a paper what the design will be globally. Some sketches were made to determine what parts are needed such as bearings, bevel gears, seals, motors, etc. After the global design is made, we began modeling with the software CATIA V5R19. All the parts needed were modeled. For some parts that we bought, the 3D cad file was downloadable online and then we can include these cads in our assembly model. If we don't have the cad file, we referred to specs sheet of the part and we modeled the part. For the modeling of the propulsion system, it's very important for us to have all the parts that will be present in the assembly. In the past, we learned that if the 3D model is not similar to what we want it to be in reality, there are chances that we have mismatches.

For the design, we began modeling the variable pitch. As it will be explained in another section, the variable pitch is designed to be in a conic rotor. The use of two bevels was decided before modeling and after, we designed the rotor depending on the decisions in the preliminary design. During the modeling, we tried to fit all the parts needed in the rotor. The other thing was that we tried to make a design that will be simple and fast to assemble and disassemble the submarine. As a result, if there is a problem with the module, we can replace it very fast with another. The challenge in designing this module was to fit all the parts in the rotor as we said but also to make it waterproof because of the presence of electrical components.

For the modeling of the gear box and all the parts connected to it, we used the 3D Cad files from the gear box of Omer 4.The gearbox consists of an assembly of bevel gears connected to a driving shaft and a pedal board. With the gear box, we modeled the other parts needed to fix the propulsion system in the submarine. In the next section, you will see the assembly of the gear and all of its parts.

3.2. *Propulsion system description*

From an outside view of the propulsion system, you can see in the figure the parts modeled to fix the gearbox in the submarine. Overall, we have a gear box, 2 plates glued to the hull, 2 structure parts, 2 gearbox cover plates and one protection tube for the driveshaft.

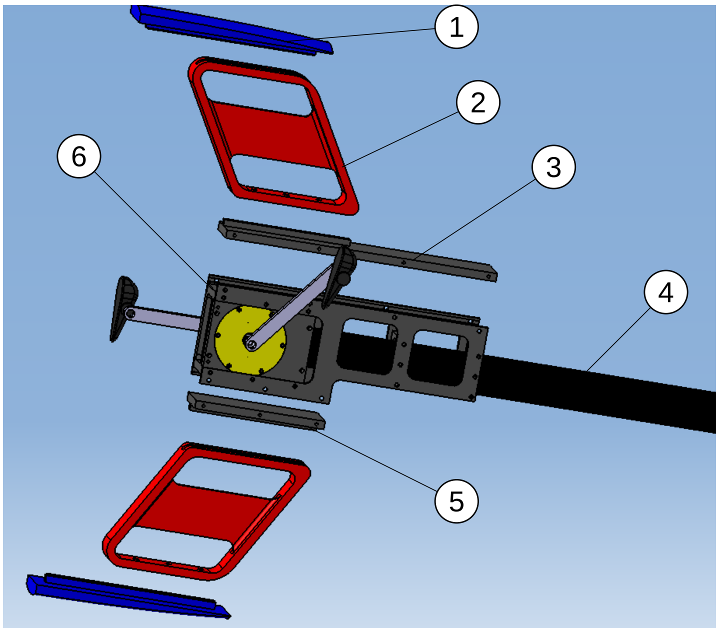


Figure 15- Components near the gearbox

1- Plate glued to the to the hull to fix the propulsion in the submarine;
2- Structure support to join the gear box with the plate glued to the hull;
3- Top cover plate of the propulsion system;
4- Tube that covers the driveshaft. Protects the driveshaft and holds the propulsion system in position;
5- Bottom cover plate of the propulsion system ;
6- Gear box which holds an assembly of two bevels gears to orient the power to the rear of the submarine.

Here is a view of what is inside the gearbox. The assembly consists of two bevel gears to orient the rotation of the pedals towards the back of the submarine thanks to a driveshaft. The bevels are designed to offer a ratio of 1 for 2 which means one turn of the pedal board will produce two turns at the driving shaft. This ratio was decided according to the design of the propeller and the average of the pedaling speed of the pilot. In the assembly, the parts are pedals, pedal levers, bearings, side plates, a gear box case, bearing covers and a button bracket shaft.

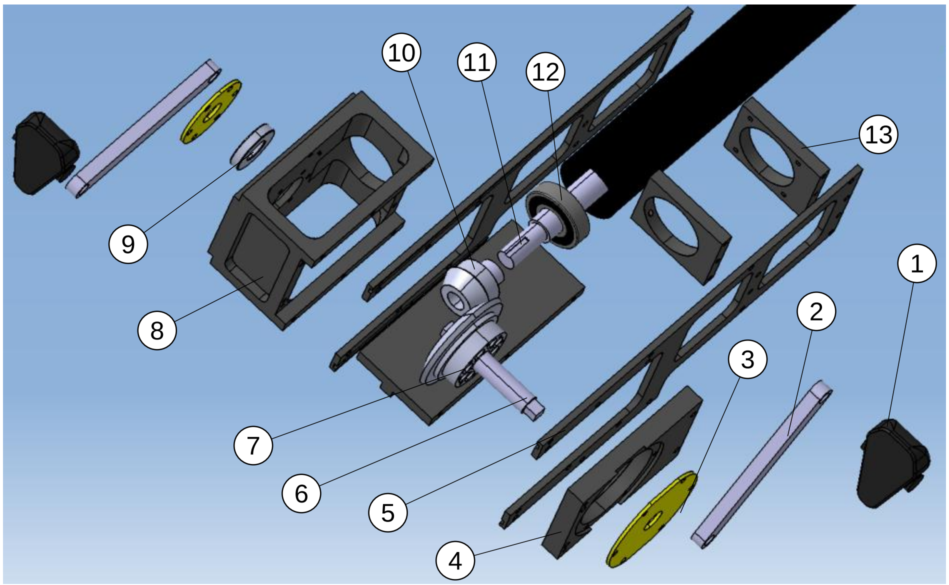


Figure 16- Components of the gearbox

Table 4- List of the components of the gearbox

1- Pedal
2-Level of crank set
3-Lateral cover Plate
4-Bearing housing
5-Lateral structure of propulsion system
6-Button bracket
7-Big bevel gear
8-Gear box case
9-Button bracket bearing
10-Small bevel gear
11-Drive shaft
12-Drive shaft bearing
13-Bracket for supporting driveshaft cover tube

In this figure, we can see a section view of the gearbox. The arrows show the sense of rotation of the bevel gear connected to the pedal board and the sense of rotation of the driveshaft.

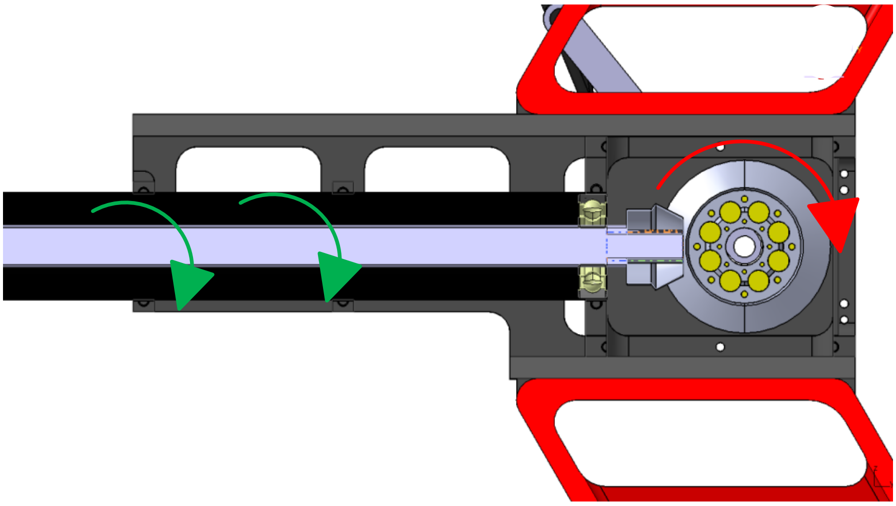


Figure 17-Rotation of the pedal and the driveshaft

3.3. *Technical specifications*

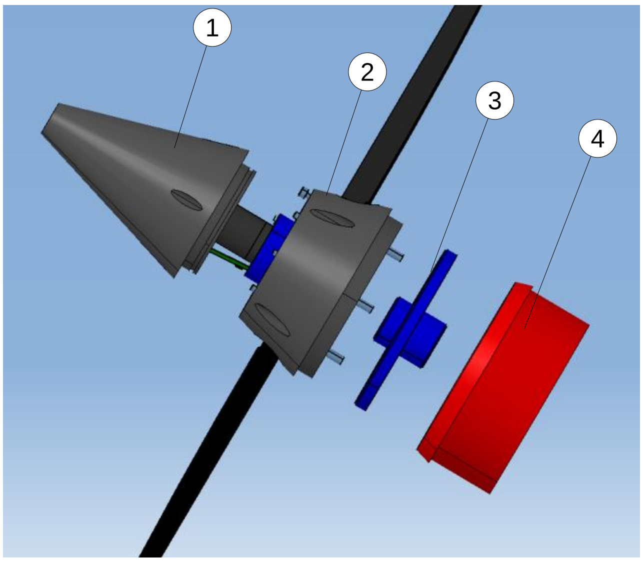
Table 5- Specification of the propulsion system

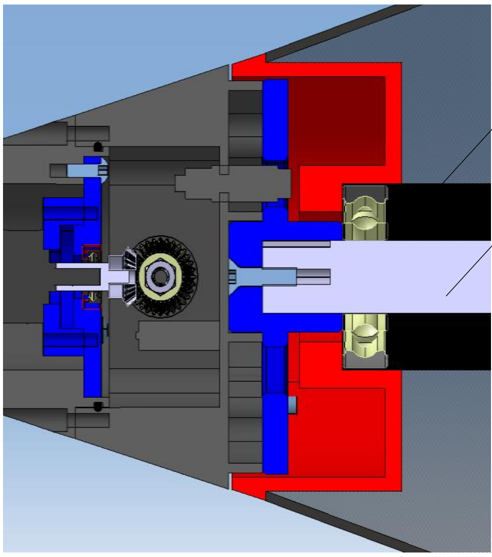
RPM Propeller	**100 RPM**
RPM driving shaft	200 RPM
Weight	50 kg
Height	24 in
Length	43 in
Material Used	Aluminum 6061 T6 aeronautic grad
Max Torque	150 Nm
Number of parts	20 parts
Length of pedal lever	170 mm
Bearing	SKF ball bearing
Pedal	Look patent pedal

3.4. *Variable pitch*

We call the variable pitch the module of the rotor which handles the propeller. The purpose of the module is to rotate the propeller and to hold the two blades in a certain angle. The reason of a variable pitch is to keep the pilot pedaling at the more effective RPM. To make a system which adjusts the angle of the blades, there is not a lot of solution. The most common used solution is a linear system controlled by an actuator. This system is used for the variable pitch of a helicopter and it has been used for Omer 4 and Omer 5. While seeking a more simple solution, we determined that we might be able to fit an electrical system in the rotor and it will be completely independent. Thus, it allows a simpler assembly and can be more precise. Furthermore, we wanted to simplify the assembly of the rotor to the propulsion system. In the other submarine, disassembling the rotor required disassembling all of the propulsion system. Since we put electrical components in the rotor and we wanted to make adjustments with the variable pitch program, we wanted the rotor to be disassembled very fast from the submarine.

Looking at the assembly, the cover tube (5) of the driveshaft (6) is inserted into the hub (4). Afterwards, the turning plate (3) is connected to the driveshaft. On the turning plate, the rotor cone (2) is screwed on. In the end, the head cone (1) is screwed to the rotor cone.





As it is shown, the hub is used to support the cover tube and is used to position the propulsion system. This part is fixed to the hull with glue so it is not moving. The turning plate is necessary to make the link between the driveshaft and the rotor cone. The reason why we do not directly connect the rotor cone to the driveshaft is that we want to be able to remove the entire rotor without disassembling the head cone and other components located in the rotor cone. The assembly is held by four screws so it is really fast to disassemble. The rotor cone contains a lot of parts such as batteries, bevel gear bearings, bearing inserts and the blades of the propeller. The main purpose of this part is to hold the blades of the propeller with the mechanism of the variable pitch. Connected to this part, we have the head cone which includes the motor and electronics to control the mechanism of the variable pitch. In the next figure you can see the parts inside the rotor cone and the head cone.

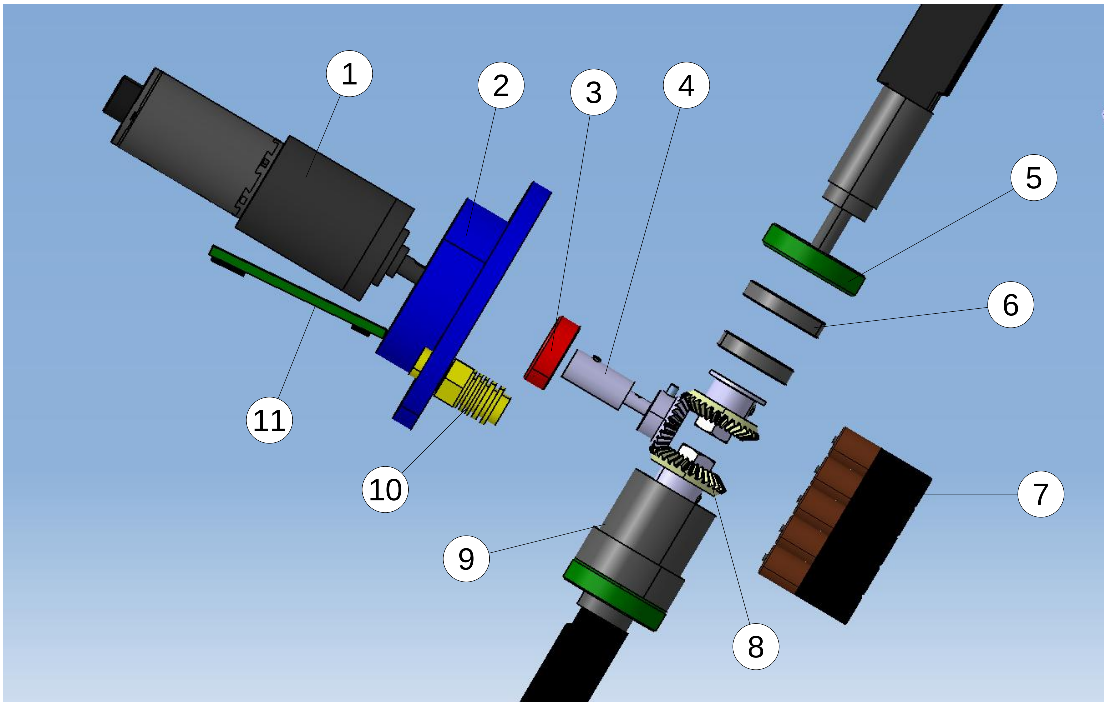


Figure 18-Components inside the rotor

Table 6 - List of the components inside the rotor

1-Electrical motor
2-Motor support
3-Seal of the head cone
4-Motor bushing
5- Seal of the rotor cone
6-Balde propeller bearing
7-Battery pack
8-Bevels gears
9-Bearing insert
10-Water proof connector
11-Electical board

The mechanism inside the rotor, shown in the figure, controls the angle of the two blades. Those two blades are assembled in two bearings to hold them in place and allow their rotation. The bevel gears are also connected to the blades. For the design, we wanted to choose bevel gears with a high number of teeth in order to have better precision and to limit loose fits. Due to the rotor cone being relatively small, we were limited in choice of bevel gears. The gears that we decided to use for the design offer a ratio of 1 for 1.3 and 35 and 29 teeth. The ratio is not very high which offers less precision. However, we decided to use an electrical motor with an integrated gearbox that has a ratio of 1 for 256. This motor is installed on a support to be perfectly placed in the head cone. The seals in the assembly are necessary to keep the entire rotor waterproof. To make sure that there is no water that goes through the motor and the electrical board, we designed the head cone to be perfectly waterproof independently of the rotor cone. The rotor cone is designed to be waterproof too, although with the blades moving, we are not sure if the seals will be waterproof. Here are some more information of the variable pitch mechanism:

Table 7-Variable Pitch components information

Battery pack voltage	**24 volts**
Motor	Maxon, 100 watts,24 volts
Bevels Gears	Cobalt
Weight	100 Kg
Number of parts	25 parts
Bearing	17mm(NSK6002), 15 mm (NSK6000)
Seal	SKF CR SEALS 6mm and 17 mm
Connector	Seacon Hummer 1.15 amps

3.5. *Functioning of the variable pitch*

As mentioned earlier, the mechanism of the variable pitch consists of controlling the angle of the blades mounted to the rotor. In the picture below we can see an example of the possible positioning of the propeller blades. The variation of the angle increases or decreases the propulsion to get maximum force out of the pilots pedaling, it`s like when you are changing speeds on a bicycle.

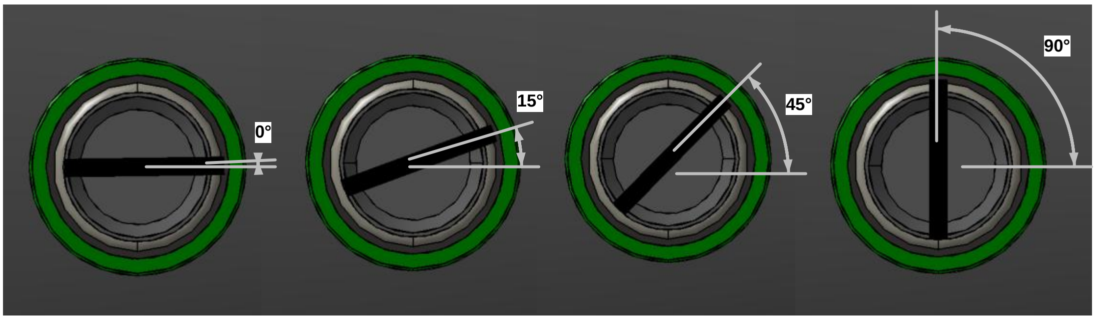


Figure 19- Different angles of blades

To simplify the explanation of the phenomenon we displayed the situation when rotor is turning in the image below. When the water hits the angled blade, it creates a force which is decomposed in lift and drag. The lift pushes the submarine forward and the drag resists the rotation of the blade. The variation of the lift and drag is influenced by the rotation speed and the angle of the blade. To increase the lift you can keep the same rotor speed and just increase the angle of the blades. In our case a lower angle will give more lift. In the picture the blade drawn flat but in reality the blades are dimensioned with aeronautics airfoil. There are limits to how much you can increase the angle. For example, if you drag horizontally with and angle of 90 degrees the drag is a lot stronger then the lift, just like try to push water aside with a flat hand. On the other hand, if the angle is near 0 degree the drag will be small but the lift will be close to non existant, it`s like slicing trough water with a sword . With our blade design, the maximal pitch angle (angle with which we get maximal lift/drag ratio) is about 20 degree. The designs of the blades of propeller are more detailed in the section 5.

The image below is an example of the variable pitch system decreasing the angle of the propeller to increase lift. We use bevel gears for the rotation of the two blades. During the rotation, the blades are hit by the fluid on different sides and thus must both be turn counterclockwise in order to get a better lift.

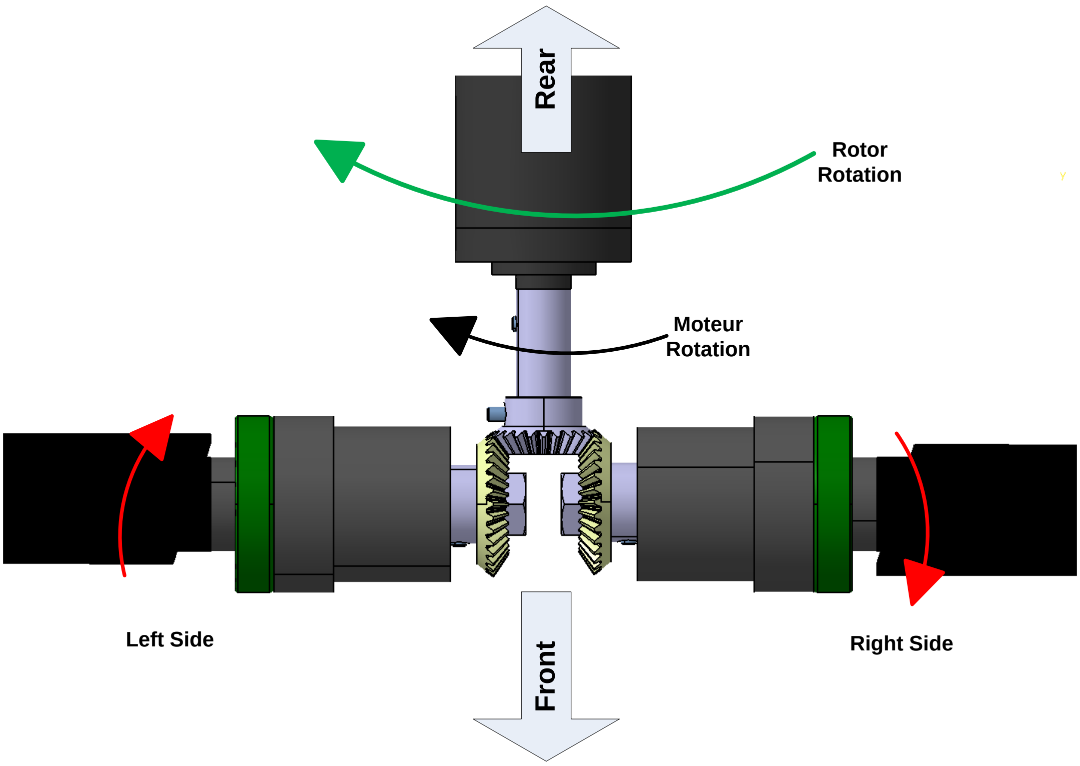


Figure 20- Way of rotation of the motor and the blades

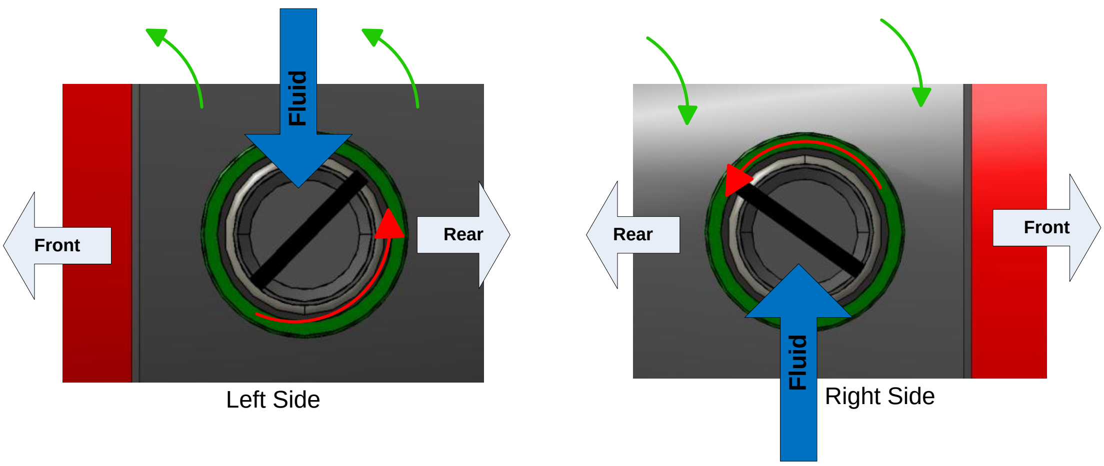


Figure 21 - Example of the variation of the angle

3.6. ***Fabrication***

The fabrication of the propulsion system is mostly involves machining custom pieces designed in 3D on Catia V5R19. For parts that need to be machined in a 3 axis numeric milling, we programmed the tools trajectories in Catia with the manufacturing feature and then we programmed it in a machine which then cuts out the piece. For cylindrical and conic parts, we use a numeric ladder called Mazak which is already programmed in our machine, so all we have to do is input the dimensions wanted. We included some pictures of the machine and parts made from the ladder in the Appendix B.

To ensure a quality, every part is inspected to insure that it will fit in the final assembly. This inspection is made with micrometers and calipers to verify if the dimensions are within the tolerated variation.

Once the machining is finished, we pass to the assembly where we recheck every piece, make sure it fits the 3d model and that it a tight enough fit that it won`t need constant tuning.

3.7. ***Electrical system***

The variable pitch is controlled by an electrical system that changes the angle of propeller blades. This system consists of a motor controlled by a programmed electrical board. The board will adjust the angle of the blades in function of the rotation speed. To evaluate the speed of the rotor a Hall Effect sensor is placed below the rotor cone and each time its passes of one of the reference holes the microchip will calculate the speed of the rotor using the time it took between two reference holes.

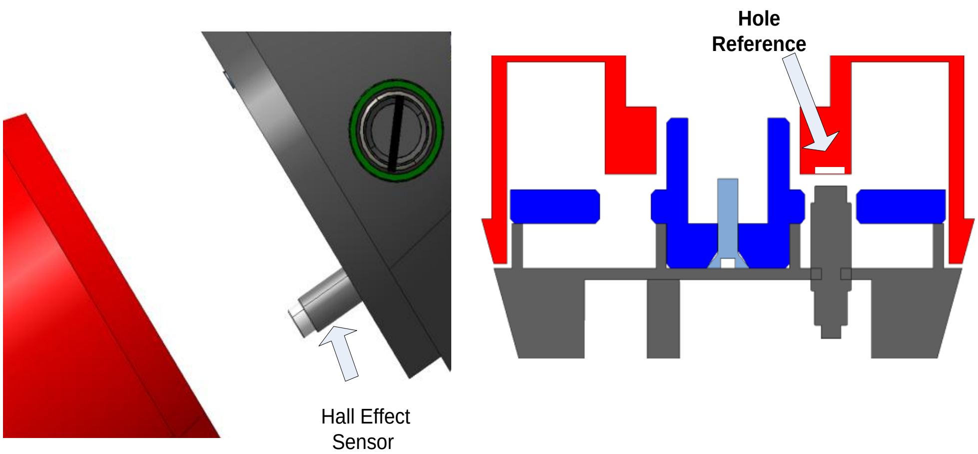


Figure 22- Hall effect sensor position

The design of the circuits and electrical boards are done in specifically designed software. We then ship the drawing to a company that fabricates the board with the electrical circuit wanted. The image below displays the electrical board that will be used in Omer 8.

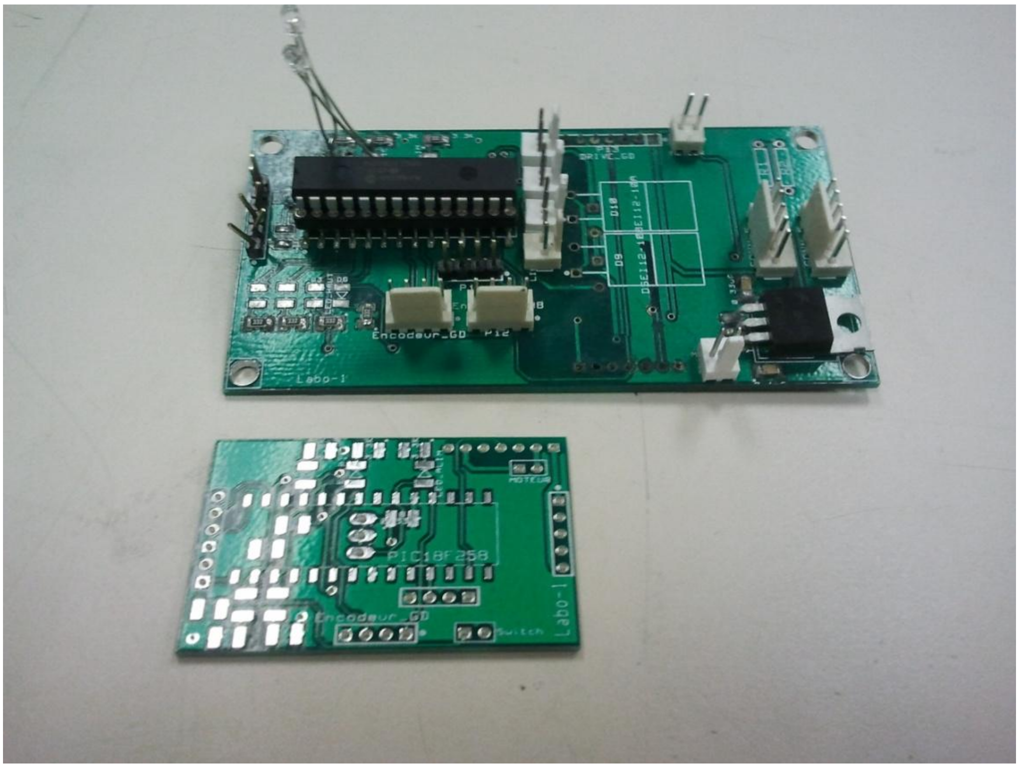


Figure 23- Direction PCB for Omer 7 (on top) and variable pitch PCB for Omer 8(on bottom)

4. Fins

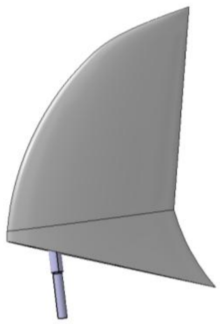


Figure 24-Fins of Omer 8

The fins are used for the direction and to stabilize the submarine. The directional fins are designed to turn on each side with an angle of 45 degrees for a total displacement of 90 degrees. The stabilizing fins have the same geometry but without the possibility of rotation. Their function is to help keep the submarine moving in a straight line and to prevent the rotation of the submarine due to the propeller force. All fins are design to be hydrodynamic when the submarine go straight forward and they are designed to offer a fast response when the pilot wants to reorient the submarine.

4.1. *Modeling*

For the modeling, we used symmetric airfoils NACA00010 with different chord length to form an ellipse shape form button to top. To generate the shape in the software we used, we drew NACA airfoils in planes placed at every inch from top to bottom. All those drawings form sections and with that we generate a surface that will be the fins shape. In this picture you can see one of those drawings of NACA airfoils.

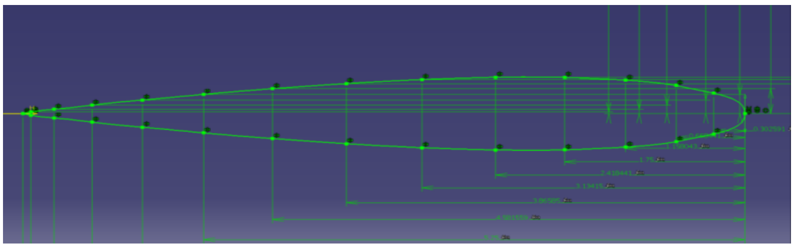


Figure 25-Fins sketch

4.2. *Fabrication*

The fins are molded with urethane plastic in an aluminum mold. The mold is all machined in a 3 axes machine programmed with the shape modeled by software. You can see the machined mold in appendix B. The molding consist to fill with urethane the slot formed by two pieces of the assembled mold. Before putting in the urethane, the shaft, the bushing and the insert are positioned to be in the right place. The shaft and the bushing are necessary for the directional fins. The shaft is fixed to the top tin and is inserted in the bushing positioned in the base section of the tin. The inserts are fixed in the base of the tins to the screw the tins and the hull together. The shaft and the inserts are machined with a conventional lathe.

5.Propeller

The blades of the propeller are designed with a Matlab program that needs some parameters to produce a shape. The parameters are the rotation speed, the diameter of the rotor, the resistance of the material used, the estimated power delivered by the pilot and the estimated drag of the hull and fins. Here is the list of the parameters and their values:

Table 8- Propeller design parameters

Rotation speed	200 Rpm
Diameter of the rotor	5.7 in
The resistance of the materiel	500 MPa (Tensile Strength)
The power delivered by the pilot	1 Hp (746 watts)
Estimated drag of the submarine	150 Newtons

With the Matlab program a type of airfoil is chosen and the angle and the length of cord of the airfoil is calculated throughout the blades length. Because the speed of fluid is higher more you distance yourself from the rotor, the angle of the airfoil near the rotor is larger than the tip. The program also does an optimization of the length of the blade and the surface area. For the modeling, the Matlab program produces points that represent airfoils disposed in 20 levels. Here are images of the points.

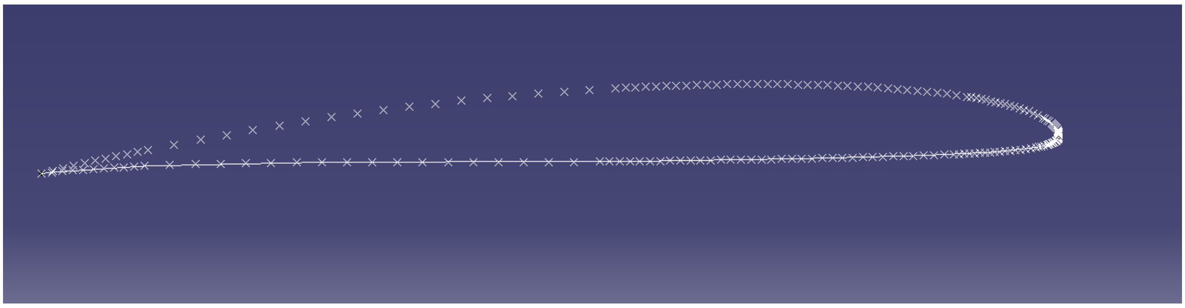


Figure 26- Points of an airfoil

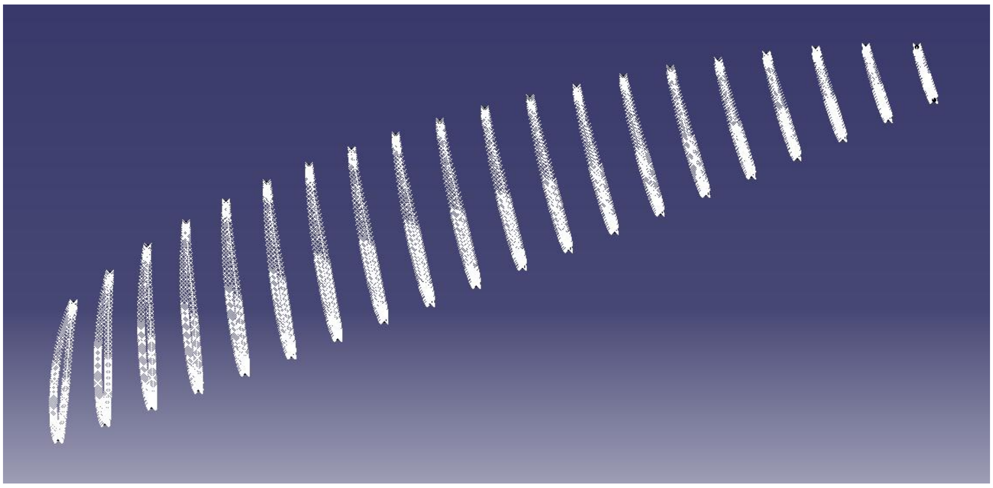


Figure 27- The airfoils on different levels

With all those points we are able to create a solid model. The 3D model will be use for the machining and the global assembly. The same technique used for the fins and the hull is used to fabricate the propeller. The final design of the propeller is suppose to give Omer8 a minimum speed of 7 knots.

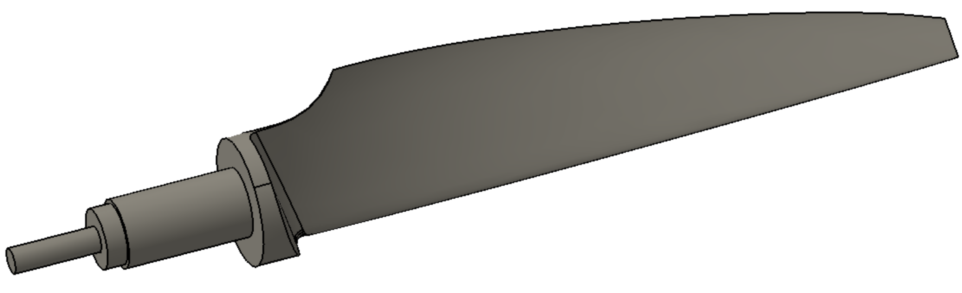


Figure 28- The 3D model of the propeller blade

6. Security system

The security system of OMER 8 is the same concept of Omer 7. It's the same pneumatic system except there are components for one pilot. This system seems to be the best design the Omer team has had because there is no need to make adjustment, it rarely breaks and if there ever was a malfunctioning, like the a tube breaks, then the buoy and the doors are automatically released. In conclusion, we noticed that it is the safest system we`ve ever had.

For the competition, a few security measures are necessary. A door opening system from the inside of the submarine, a "dead-man switch" and a buoy that will be automatically launched by the pilot in case of distress are required security measures for all teams participating in the races. In OMER 7, the system consisted of releasing a buoy from a door situated at the back; the concept will be reused in Omer 8. The system is redundant and designed to avoid failures; the triggering mechanism of the buoy is combined with the door opening system in order to facilitate the rescue our pilot and ensure that the pilot doesn't get stuck in the submarine if ever there is a system failure.

6.1. ***System operation***

Here is a brief summary of operating requirements:

Figure 29 - Requirements and operation of security system

Systems	Operations	Requirements
Doors opening system	Order the doors open when the pilot inside the submarine wishes	• The driver opens the doors by pressing a button in order to coordinate efforts at the end of the race and for the security. • The lock system is operated by a system of pneumatic cylinders.
The triggering mechanism of the buoy	Order the doors open and the triggering of the buoy if the pilot loses consciousness or is in distress.	• Pilot must maintain in position at all times a button pressed. When this valve is released, the buoy and the doors of the driver are released. • In case of system failure, it must be impossible to be trapped inside the submarine.

6.2. *Presentation of the pneumatic diagram*

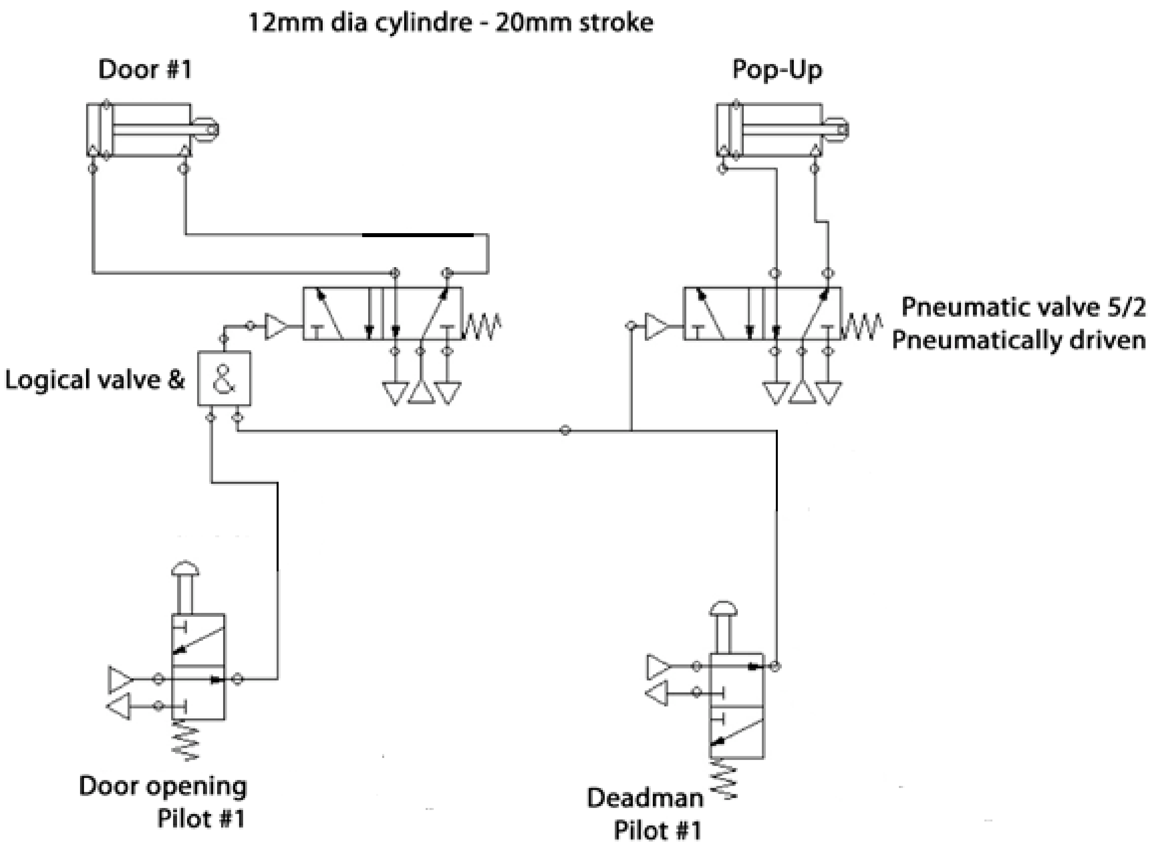


Figure 30 - Pneumatic system's diagram

The schematic of the system in figure 51 shows the different components used and the connections needed in order to do the actions wanted. The manual valve at the right is for the triggering of the safety buoy while the valve at the left will be used for the door opening. It can be easily seen that if the security valve is released, the door are released and the safety buoy is launched. It is important to clarify that the ejection of the doors is done by the withdrawal of the cylinder. Moreover, if one of the air ducts is disconnected at any point in the system, the cylinders automatically release the doors.

6.3. *Design of the doors opening system*

The mechanism used for opening doors is composed primarily of a pneumatic actuator, a linear rail and a spring. The cylinder is supplied with air by the circuit shown in figure 25 and is shown in figure 26. The linear rail serves here as a slide to facilitate the opening of the door and must be dimensioned correctly to take the moment imposed by the clasp. The spring is used to prevent a pilot to be trapped in the submarine. Thus, if a lack of air occurs, opening of the door will be done automatically. Moreover, the mechanism must be removable to allow the installation of the propulsion in the submarine.

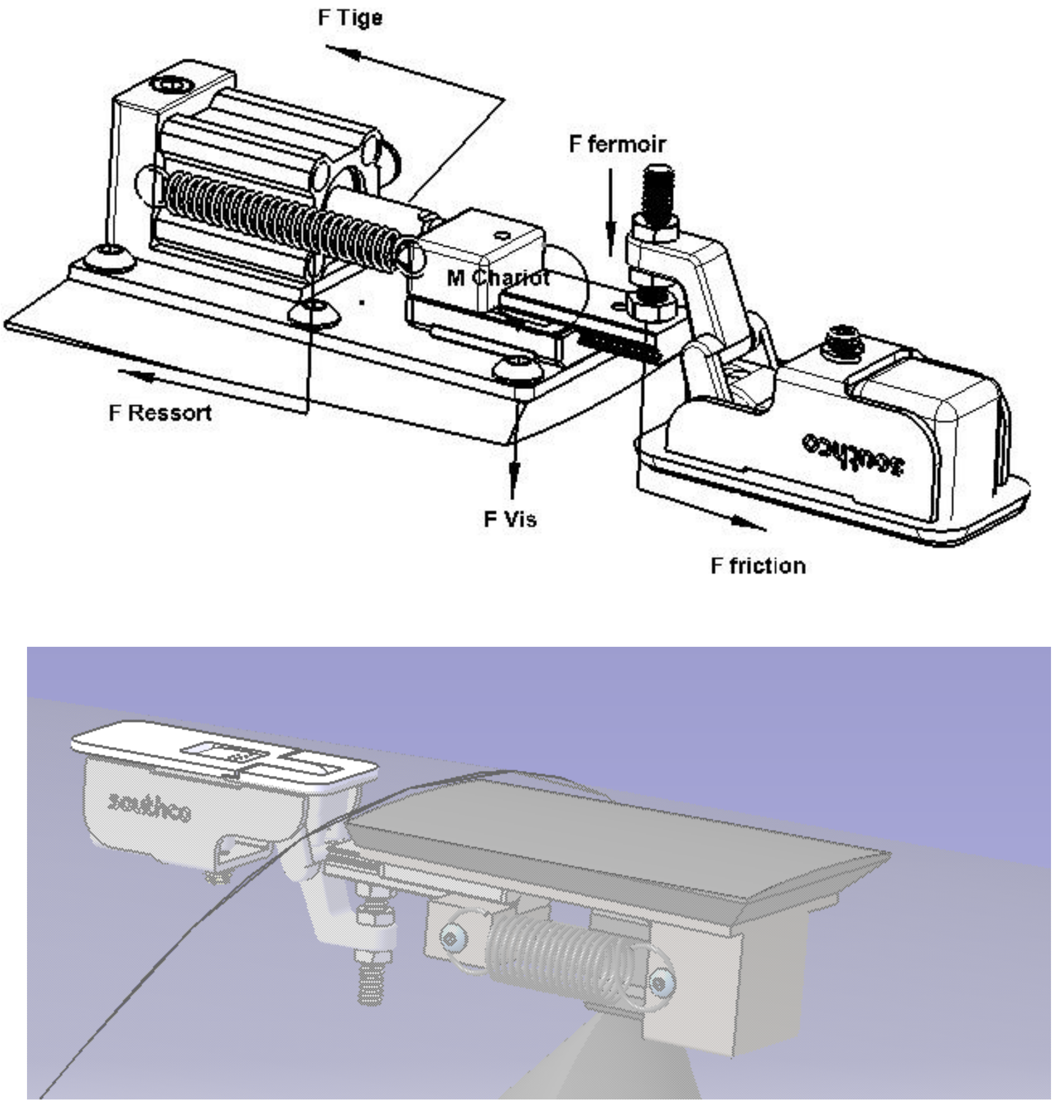


Figure 31 - Modeling of closing mechanism

6.4. *Placement of the elements in the submarine*

Figures 27 show the location of major components in the submarine. Feeding tubes and valves of logic were not modeled because the size of these components is negligible.

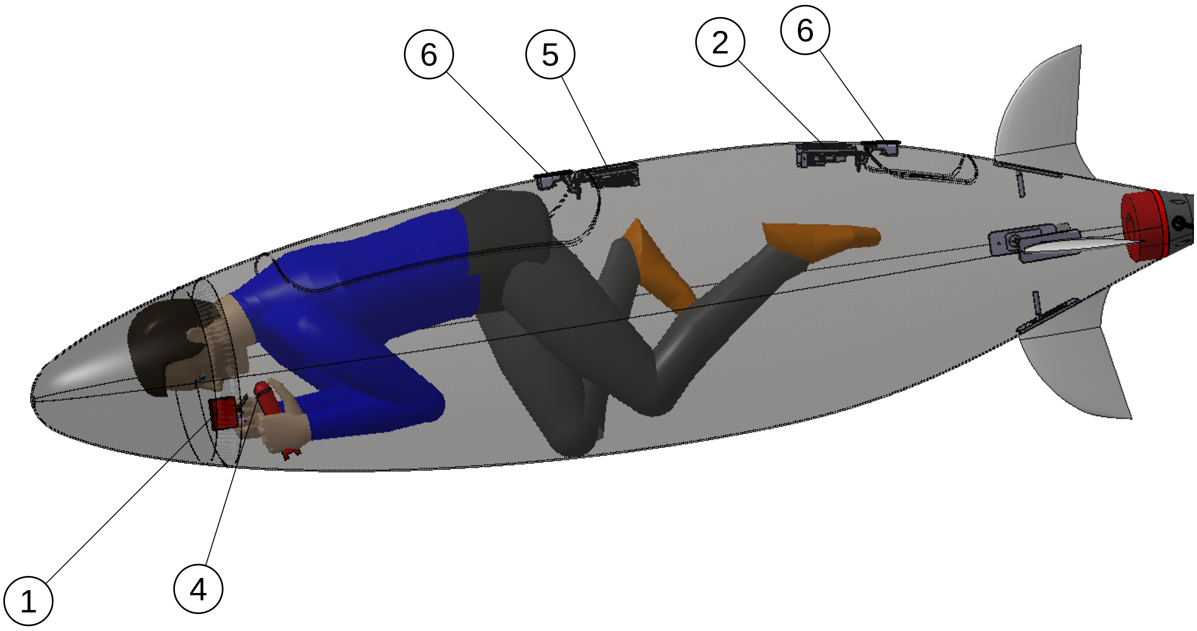


Figure 32 - Components seen from the front of the sub

Table 9 - Safety system detail

NO.	QTE.	NOM	DESCRIPTION
1	1	Door opening valve	**NVM230-N02-08**
2	1	Pop-up buoy switch	**Manufactured (OMER)**
3	1	Air container 13 PI^3	**Already in stock**
4	1	Dead-man switch	**Manufactured (OMER)**
5	1	Door releasing system	**Manufactured (OMER)**
6	2	SOUTHCO Latch	**SOUTHCO**
7	**2**	5/2 pneumatic valve	**SYA5120-01T**

7. Direction

7.1. *Mechanical direction*

The mechanical direction is used to allow the pilot to lead the submarine right/left as well as up/down.

The mechanical direction is made of two parts: The joystick that converts the hand movements of the pilot into a translation movement of the cable and four cables, 2 for up/down and 2 for right/left, that transfer the movement from the front to the back of the submarine. The cables enter the rear transfer case that converts the pull movements of the cables to a rotation movement of the fins.

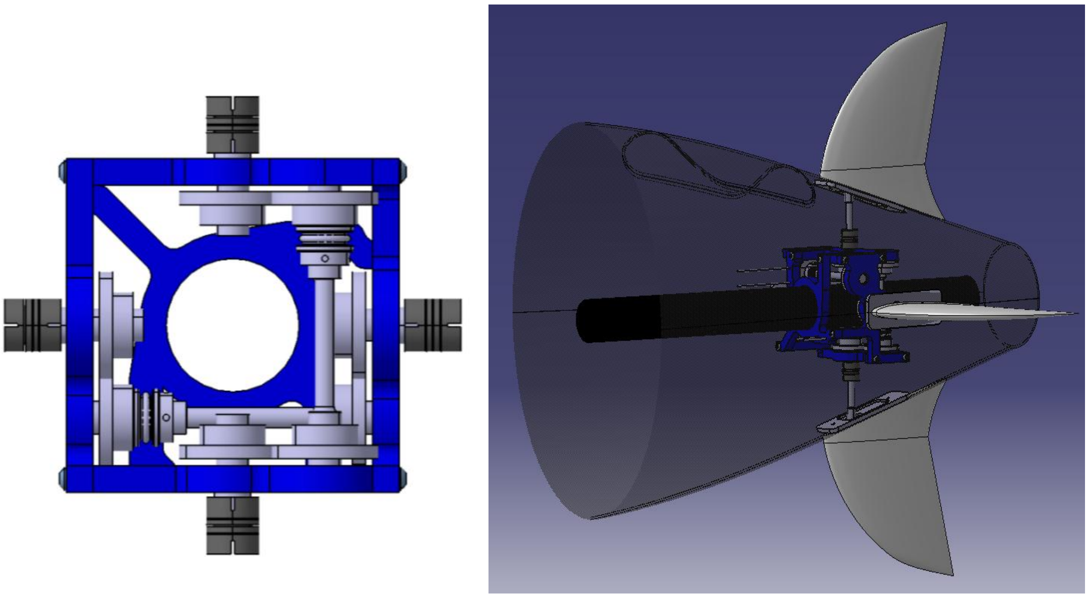


Figure 33- direction's gearbox

7.2. *Rear transfers case*

The rear transfers case in one of the two main part of the OMER 8 directional system. It's the part that converts the movement from the cable to the fins. The constraints were the size of the case to be able to fit inside the hull, to have place for the propulsion system to pass through in the center of the transfer case and to have all 4 fins on the same plane.

Two small shafts are attached to the fin and to the mains shaft through a gear system (see picture). This gear system ensures the exact same displacement for the two right/left fins. It's also possible to give a slightly different angle to just one fin to counter the torque of the propeller. The cables that come from the joystick are wrapped around the mains shaft. If you pull the right or left cable, the main shaft turn, which then makes the two small shafts and the fins turn. The gear system was chosen because it allows possibility of very large angle variation. The exact same system is used for the up/down controls.

Here is a picture of the rear gearbox that explains how it works. The yellow arrows show the movement of cable, the red arrows shows the way of rotation of the main shaft and the green arrows shows the rotation of the couplings connected to the fins.

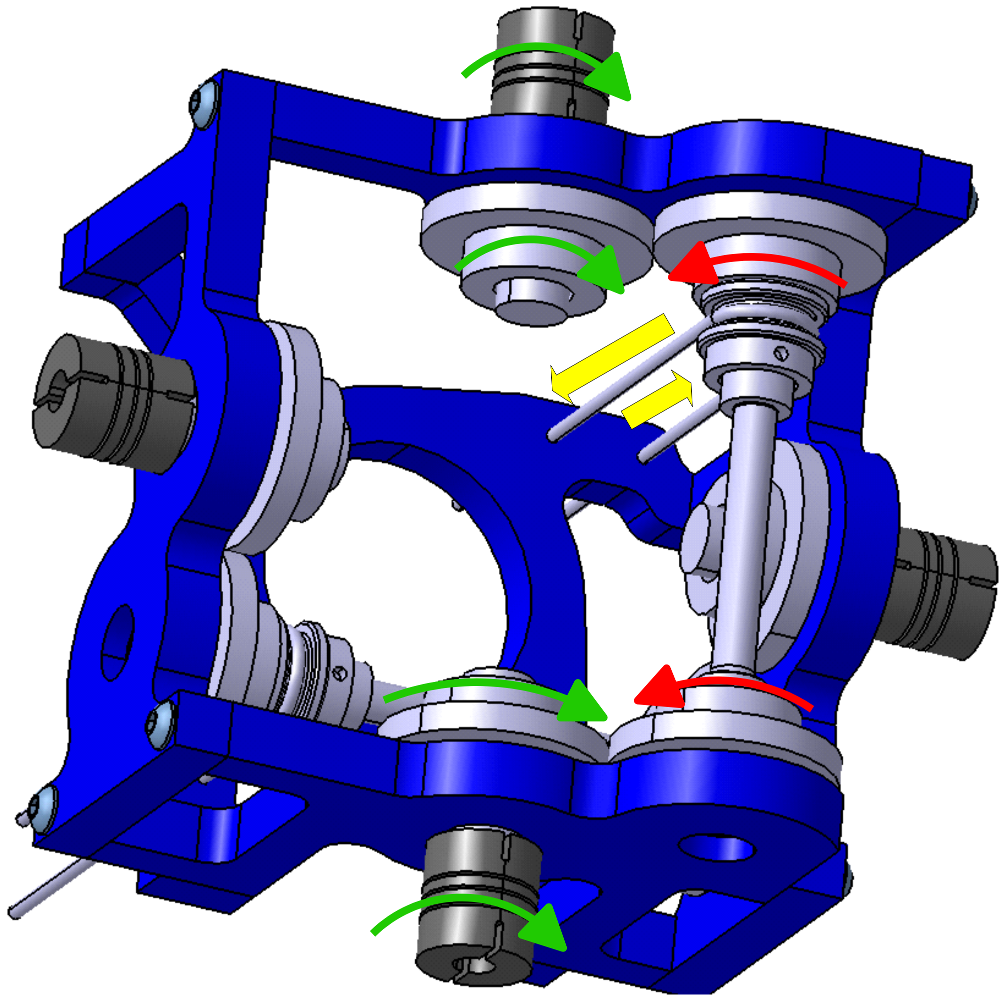
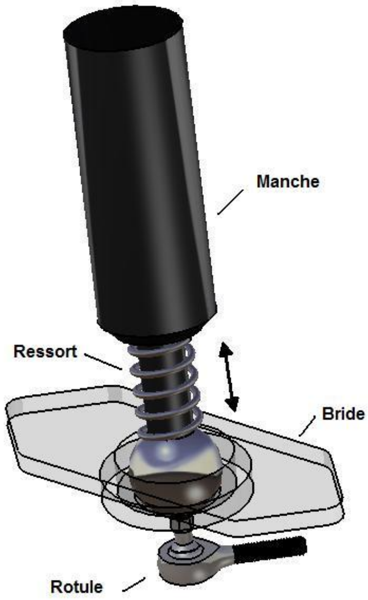


Figure 34-Way of rotation of the rear transfer case

7.3. *Mechanical Joystick*

A ball is inserted into a flange. A spring puts tension on the ball so that it remains in contact with the flange. Thus, when the handle rotates, the ball slides on it, the spring contracts and the clamp move in the desired direction (see Figure 1).



When the flange needs to move, ball bearing slides decompose the motion into two movements (see Figure 1.1 and 1.2). The top slide allows the clamp to move in all directions while the bottom slide allows forward movement on the cables attached to the supports. Thus, if the driver rotates the handle diagonally, two linear bearings travel beneath, decomposing the movement in two axes (same principle as the decomposition of a 2D vector).

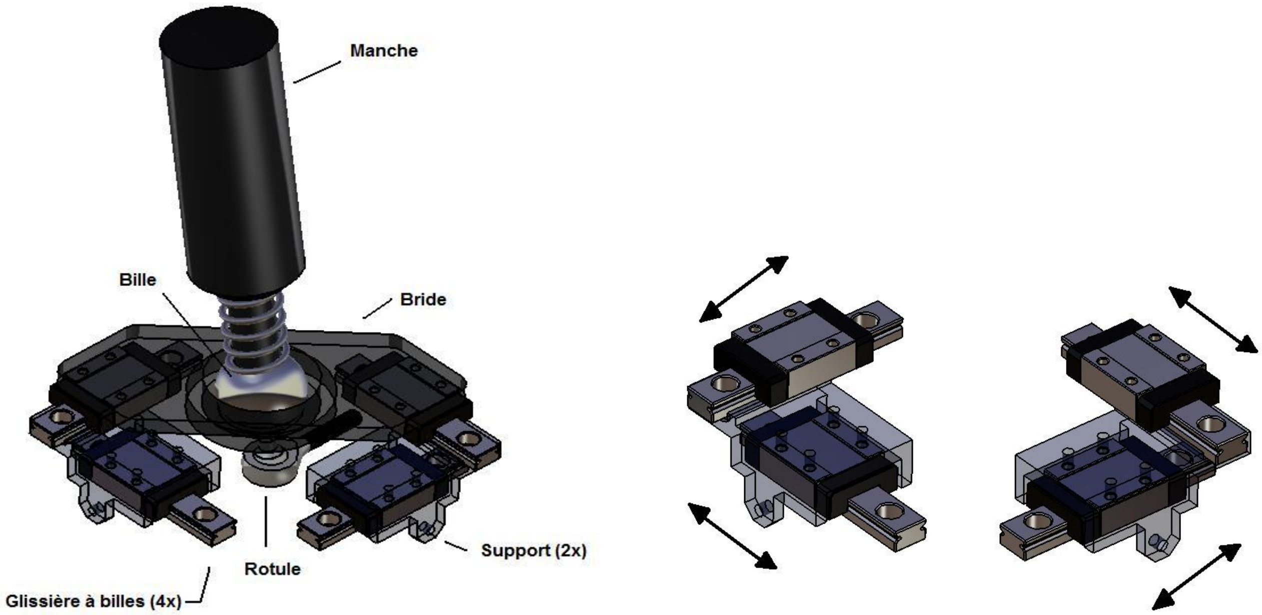


Figure 35- Joystick mechanism

8.Conclusion

All the elements of the submarine Omer 8 have been presented in this report. We explained the hull modeling and fabrication, the propulsion system with the variable pitch, the fins, the propeller, the security system and the direction system with the joystick and the gearbox. All these designs are made in target to beat the speed record of Omer 4. With the smallest hull, with the propulsion system similar to Omer 4, with a simpler variable pitch and with a propeller designed for a minimum speed of 7 knots we think that our goal is within our reach.

We hope that this report helped you to admire our design of Omer 8.

9.Appendix A

Table 10-List of the Omer members

Last Name	First Name	Code Permanent	Concentration
Abdallah	Soumaya	ABDS22578501	Mechanic (3^{e} year)
Baril	Francis	BARF12098707	Electric (4^{e} year)
Barry	David	BARD25018805	Mechanic (3^{e} year)
Barthe	Guillaume	BARG19048305	Mechanic (4^{e} year)
Daudelin	François	DAUF16018500	Mechanic (1ère year)
Dubé	François	DUBF27128604	Mechanic (4^{e} year)
Dubois	Gabriel	DUBG30028808	Mechanic (2^{e} year)
Du	Vinh		Cursus
Gagnon	Tommy	GAGT14098503	Master
Gélinas	Alex	GELA02058601	Mechanic (4^{e} year)
Guillemette	Jean-Sébastien		Electric (2^{e} year)
Lerebours	Anne-Christine		Mechanic (1ère year)
Lévesque	Bruno	LEVB03028709	Mechanic (4ère year)
Lévesque-Landry	Kevin		Electric (2^{e} year)
Picard	Alexandre	PICA28068700	Mechanic (4ère year)
Quevillon	Sébastien	QUES25068800	Mechanic (3ère year)
Selwood	Stephan	SELS31038809	Electric(1ère year)
Vachon	Katrina		Cursus

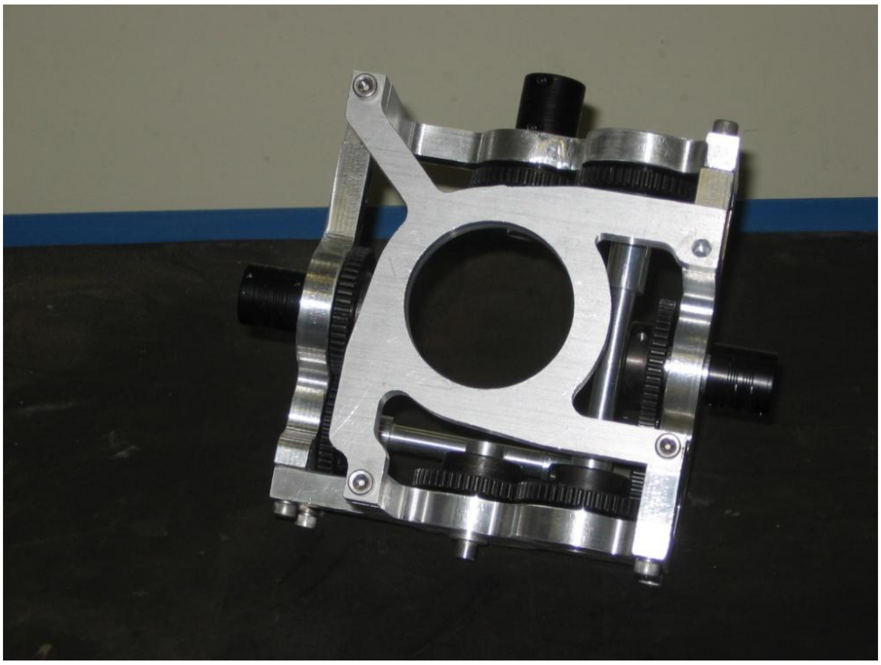
10. Appendix B

Figure 36-Variable Pitch machined parts

Figure 37- Machining of the head cone

Figure 38-Machinging of the propulsion support

Figure 39-The propulsion system assembled



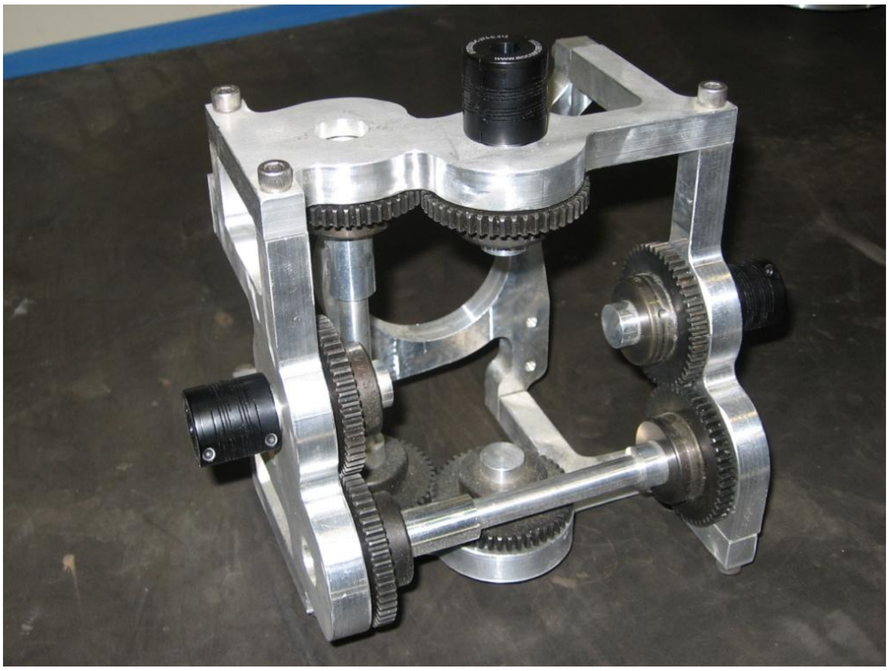


Figure 40-Direction gearbox machined and assembled

Figure 41- two machined joysticks

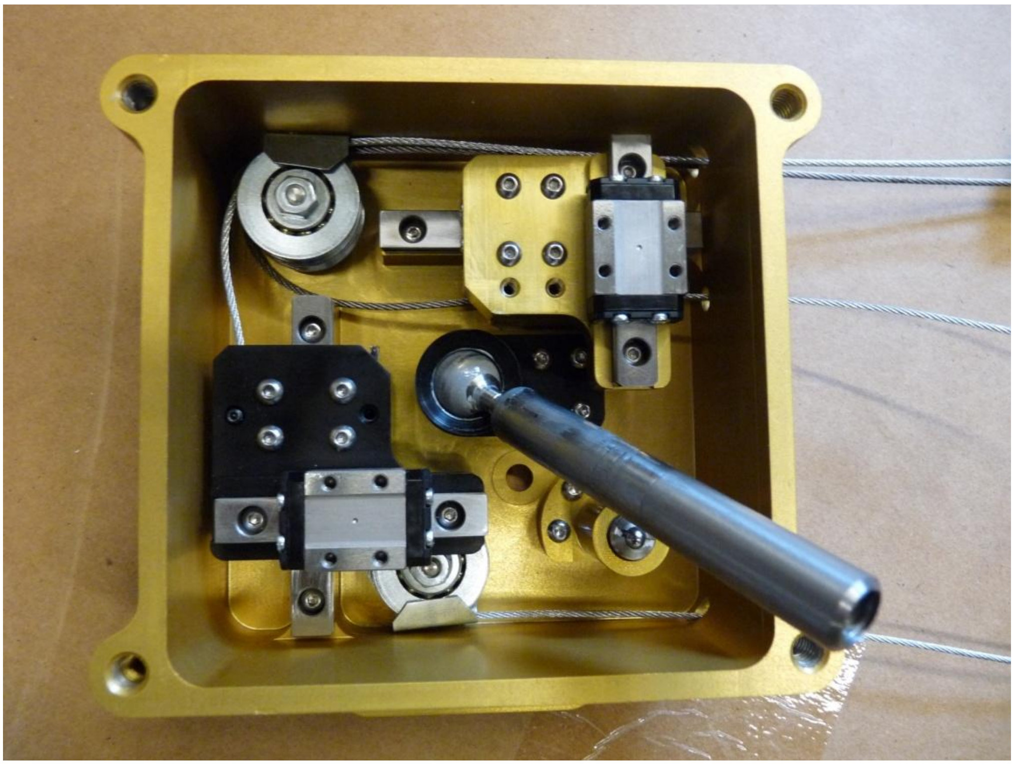


Figure 42- Inside the joystick

Figure 43- The direction system assembled in the submarine

Figure 44-The direction assembled at the back of the submarine

Figure 45- Fins machined mold

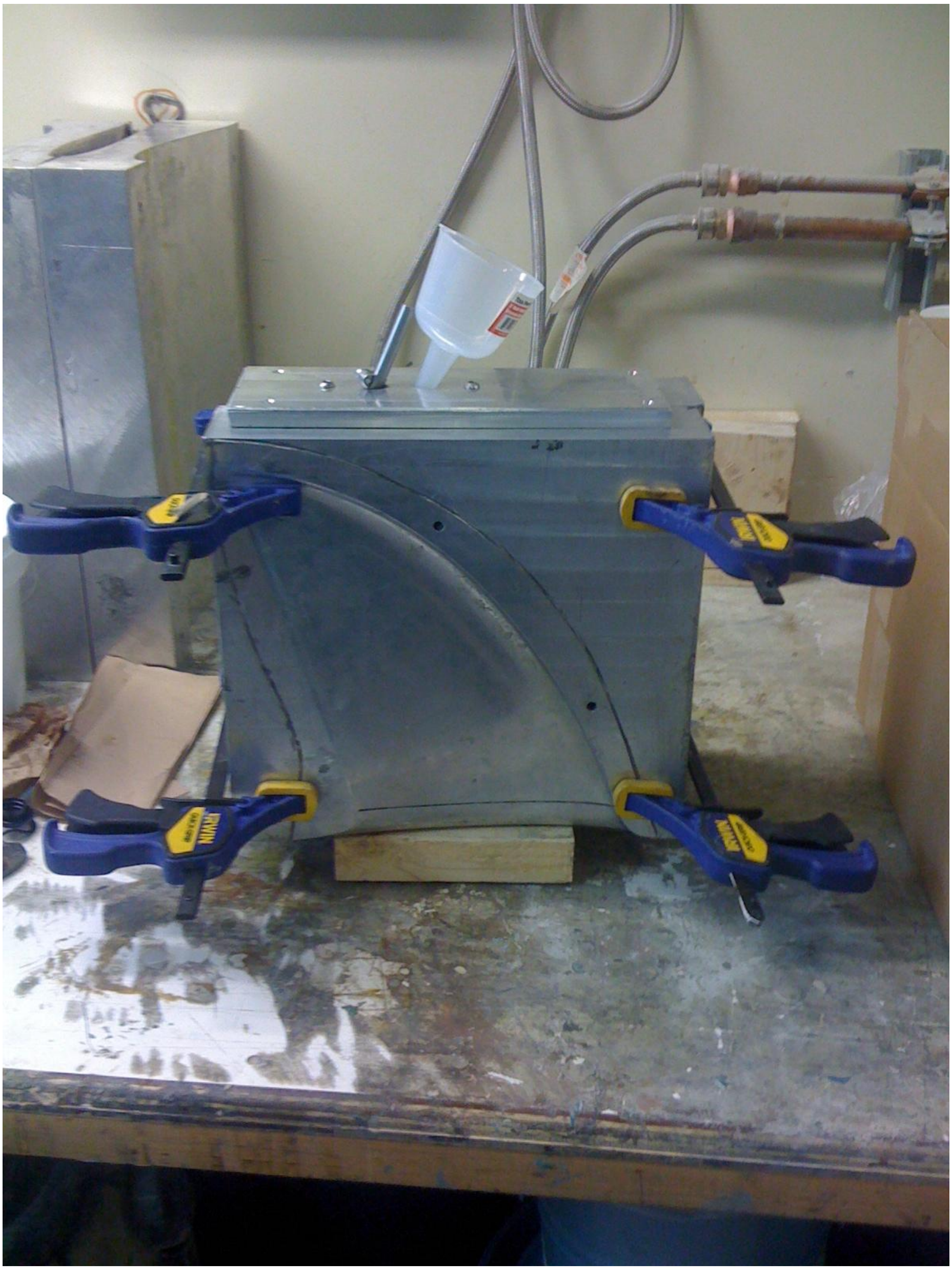


Figure 46-The molding of the fins

Figure 47-Molded fins

Figure 48-Machined mold of the hull

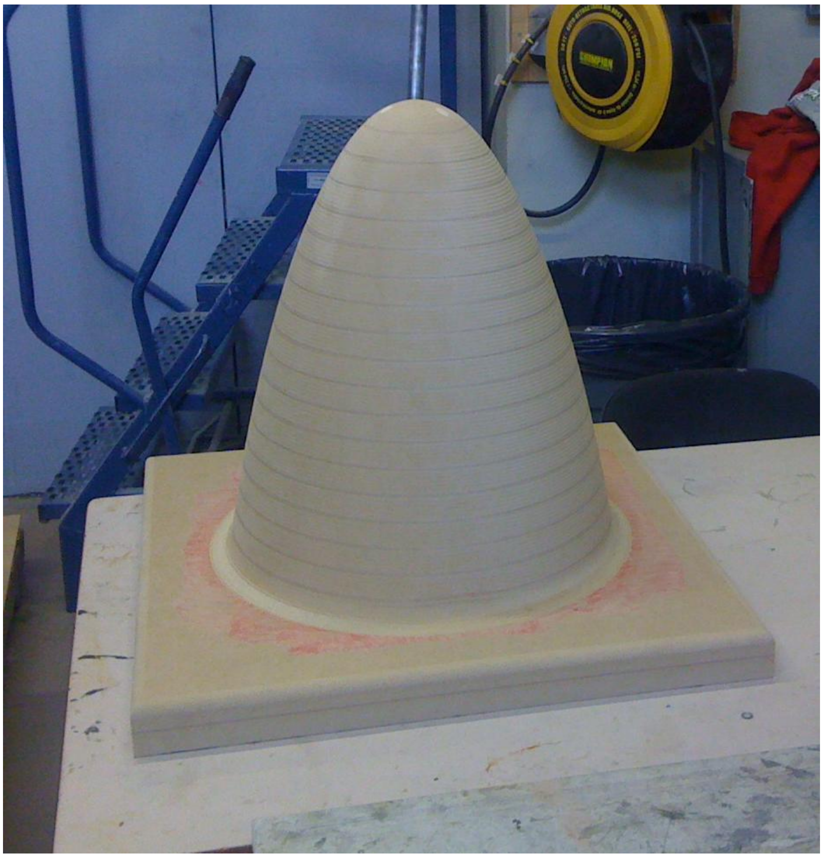


Figure 49-Front window mold

Figure 50- Painted mold of the hull

Figure 51-The mold with a clear coating

Figure 52- Placing the carbon fiber in the mold

Figure 53-Positionning the foam

Figure 54-Placing the peal ply and the tubing

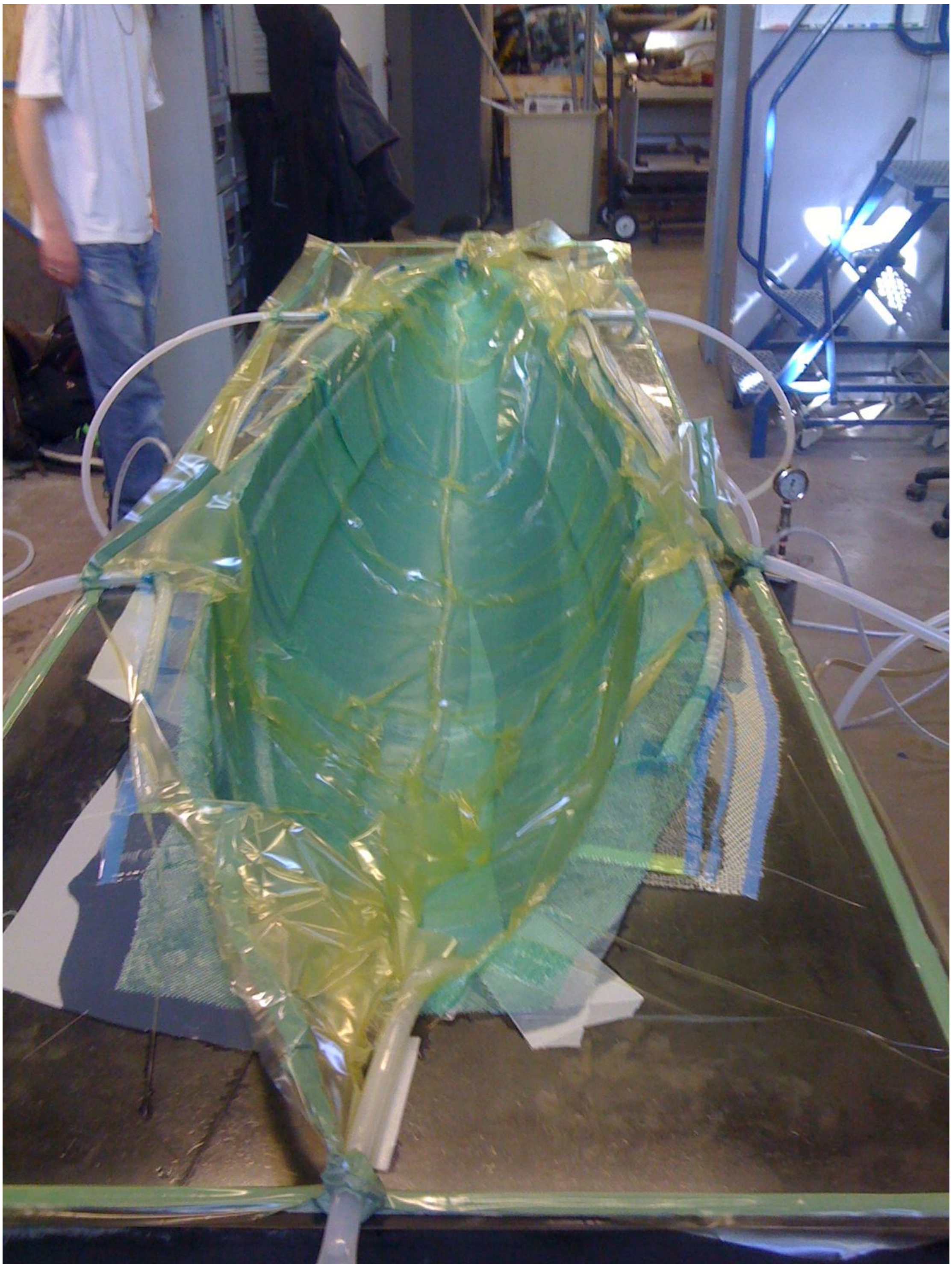


Figure 55-The bagging of the mold

Figure 56-First look of Omer 8

11. Appendix C

The Sponsors

Carbon fiber supplier:

Foam and resin epoxy supplier:

Acessories for composite supplier:

The wood molds are machined by:

All the metal for the machining is offer by:

The anodizing of the aluminum parts is made by:

The pneumatics parts for the security system are supplied by:

The front window is molded by:

The electrical boards are made by:

The bearings are offer by:

The rental of diving equipment is offer by: