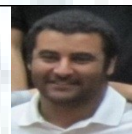
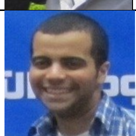
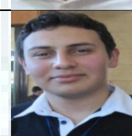
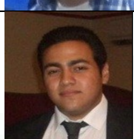
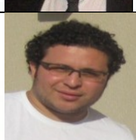
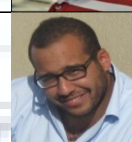
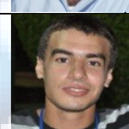
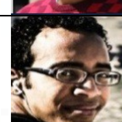
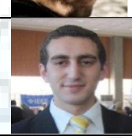
AASTMT ROV

Arab Academy for Science, Technology & Maritime Engineering
Alexandria, Egypt

	**Mohamed Fawzy (Electronics &Co-Pilot)** Computer Engineer		**Galal Ibrahim (Mechanical &PILOT)** Mechatronics Engineer
	**Mohamed Mahrous (Mechanical &CEO)** Mechatronics Engineer		**Ahmad Rami (Mechanical)** Marine Engineer
	**Salah Mohamed (Mechanical)** Mechanical engineer		**Abdulrahman Jamal (Mechanical)** Mechatronics Engineer
	**Hazeem El-Maraghi (Electrical)** Mechatronics Engineer		**AlaaSherif (Mechanical)** Mechatronics Engineer
	**KarimGamal (Electrical)** Electrical Engineer		**Ashraf Abdelaziz (Electronics)** Electronics Engineer
	**Momen Mohamed (Mechanical)** Mechanical Engineer		**Mohamed Elbanna (Mechanical)** Mechanical Engineer
	**Ahmed Zaghloul (Mechanical)** Mechanical Engineer		**ZiadMoustafa (Mechanical)** Mechanical Engineer
	**Mohannad Mohamed (Mechanical)** Mechanical Engineer		**Mohamed Elhalwagy (Programming)** Electronics Engineer
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	**Eng. Mohamed Fouad (Mentor)** Computer Engineer		

Abstract

RECFRS is the name of the latest version of the Arab Academy for Science, Technology and Maritime Transport (AASTMT) Remotely Operated Vehicle (ROV) that operates underwater. It is designed to compete in the Marine Advanced Technology Education (MATE) International ROV Competition for the year 2012.

AASTMT participated last year for the first time in the MATE international competition with the "TAHRIR" ROV where much experience has been gained from interacting with other teams. This time AASTMT-ROV team refers to the guidance of experts in the field to solve problems that has been faced in earlier ROV to produce the current version.

RECFRS frame is designed in order to keep the ROV stable and to let it has a high ability to maneuver. Bilge Pumps are used as thrusters (5pumps) to control forward, backward, side and steering movements. One bilge pump has been modified to actuate the propeller of up and down movements. A manipulator is designed to satisfy missions that have to be done by ***RECFRS*** in addition to extensions for sensors as well as fuel tank mission system.

RECFRS is control is designed to be user friendly via controlling its motion and manipulator using SONY's PlayStation joystick (after some modification in its circuitry) in addition to three CCD underwater cameras which are supported to guarantee suitable vision for the navigation team.

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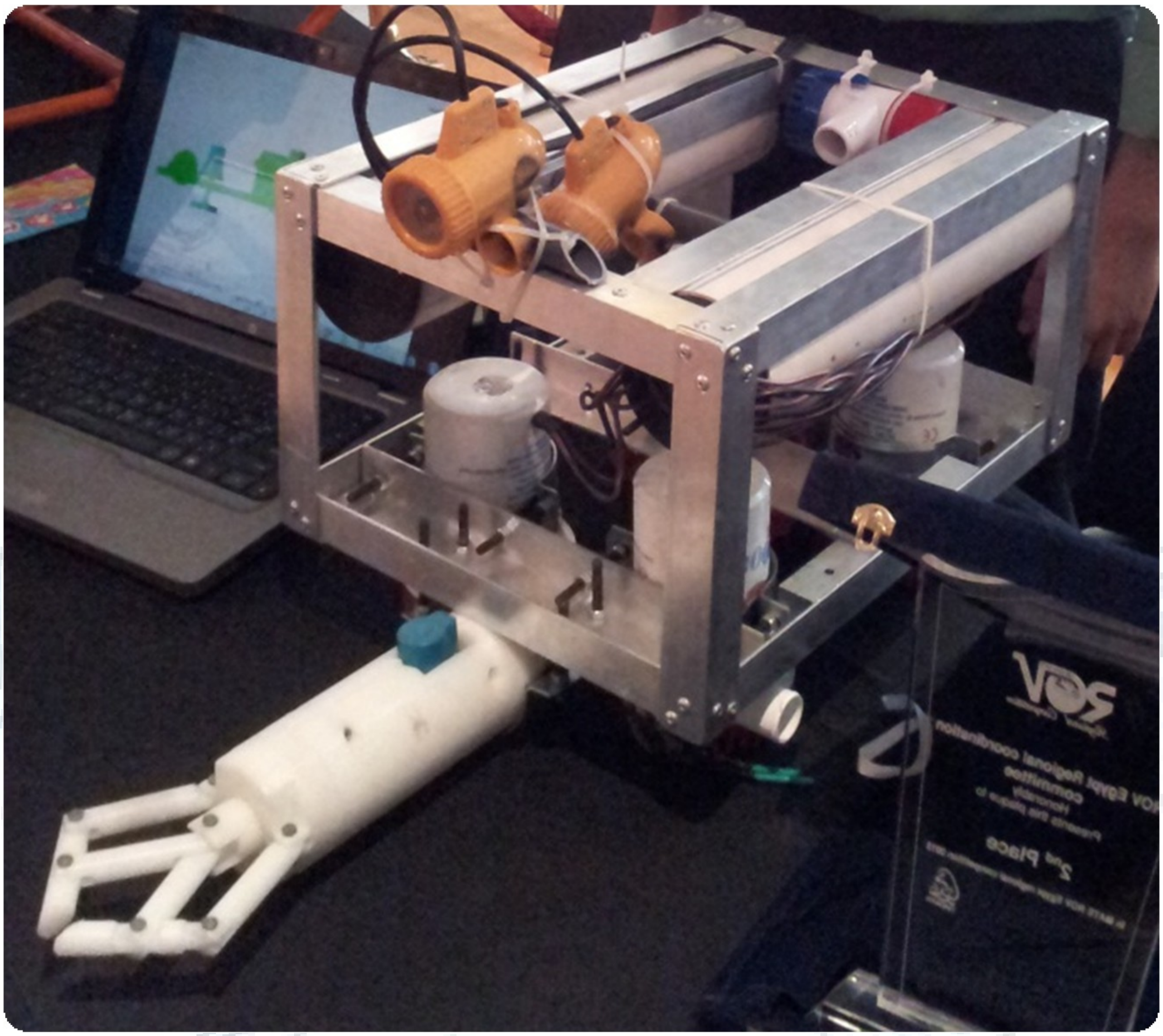
1. ROV Photograph

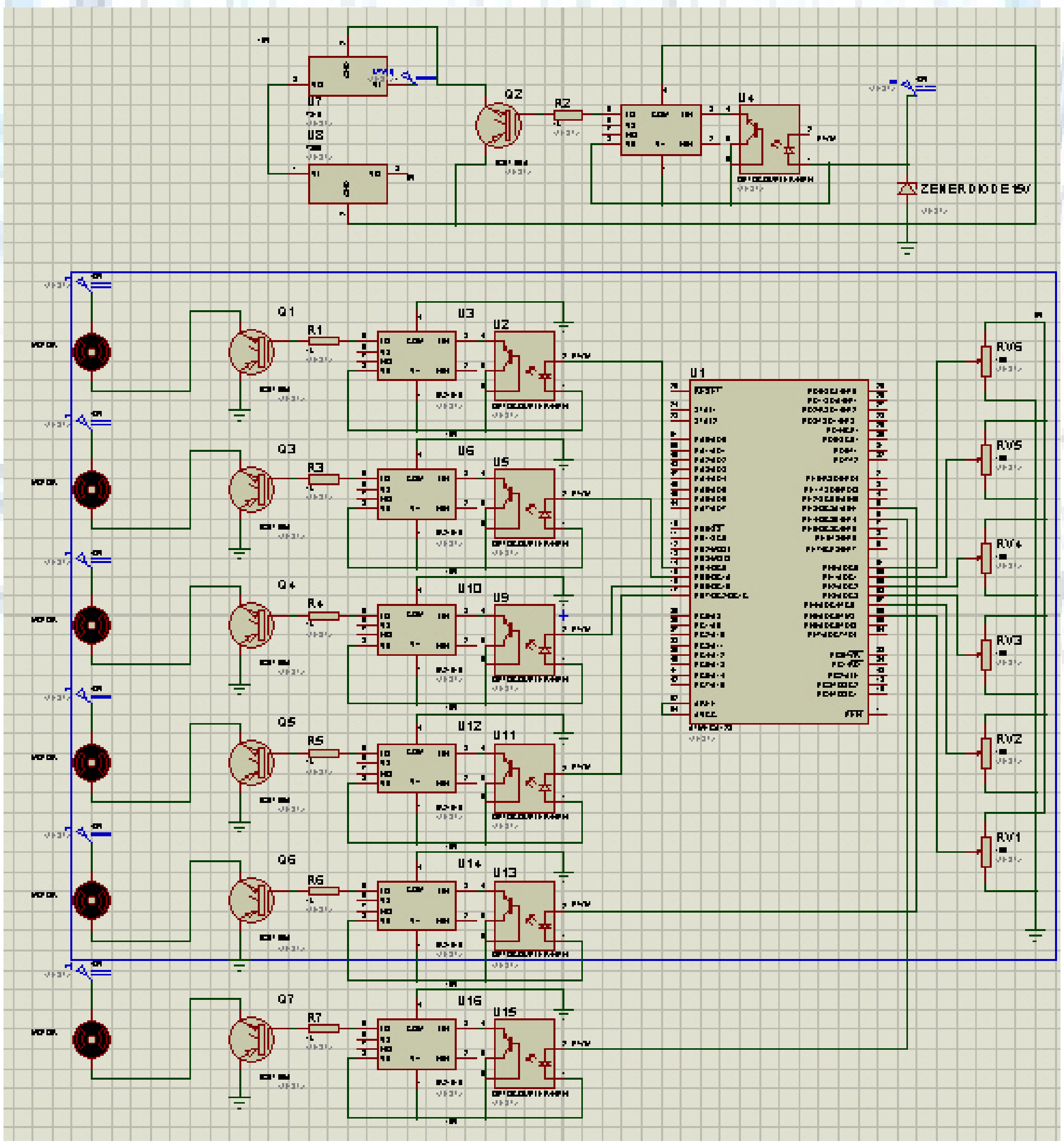


2. Budget/Expense Sheet

ROV Construction				
Item	**Quantity**	**Price/unit**	**Total price**	
Motors 24 v	4	600	2400 EGP	
Motors 12 v	2	300	600 EGP	
Center lock	1	18	18 EGP	
Bolts and Nuts	0.5 kg	40	40 EGP	
Aluminum	5.8 meter	20	100 EGP	
IGBT	8	30	240 EGP	
PCB	3	30	90 EGP	
Electronics (res,cap,...etc)	n/a	n/a	350 EGP	
Robotic arm		n/a	300 EGP	
Cameras	3	750	2250 EGP	
Hand pump	1	200	200 EGP	
Tether	30 meter	20	600 EGP	
PVC pipe	1 meter	20	20 EGP	
Tube cap	10 piece	25	250 EGP	
Rubber	2 meter	15	30 EGP	
metallic belt	5 piece	5	25 EGP	
TRAVLE				
tickets	6	9200	55200 EGP	
hotel	4 *6 Days	308	1848$	
TOTAL				
ROV Construction			7513 EGP	1243 $
Travel			66288 EGP	10957 $
TOTAL			73801 EGP	12200 $

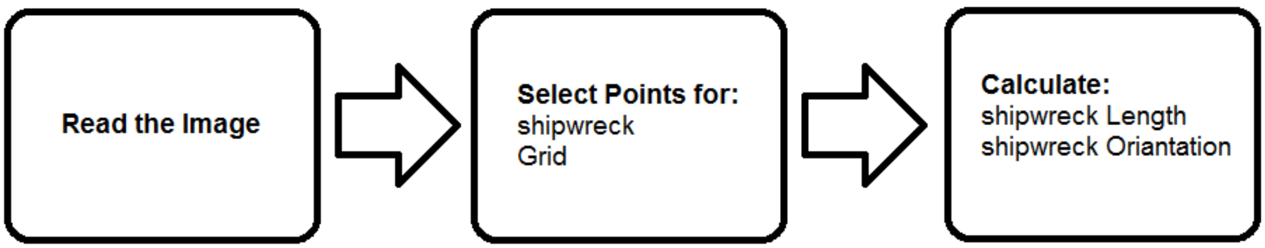
3. Electrical Schematic

The controlling System in RECFRS divided into subsystems; these systems are used to feed the propulsion system, cameras, proximity sensor and the electronics circuits. The Pulse Width Modulation (PWM) technique is used in order to reduce the input voltage (48 VDC) into different voltage levels. The voltage conversion circuits composed mainly of Insulated Gate Bipolar Transistor (IGBT) that is derived using MOSFET driver. The variation of the duty cycle of timers which derives MOSFET derivers will produce the different required voltage levels. This is a much less expensive, more flexible and much less circuit weight and size than the DC to DC voltage converter.

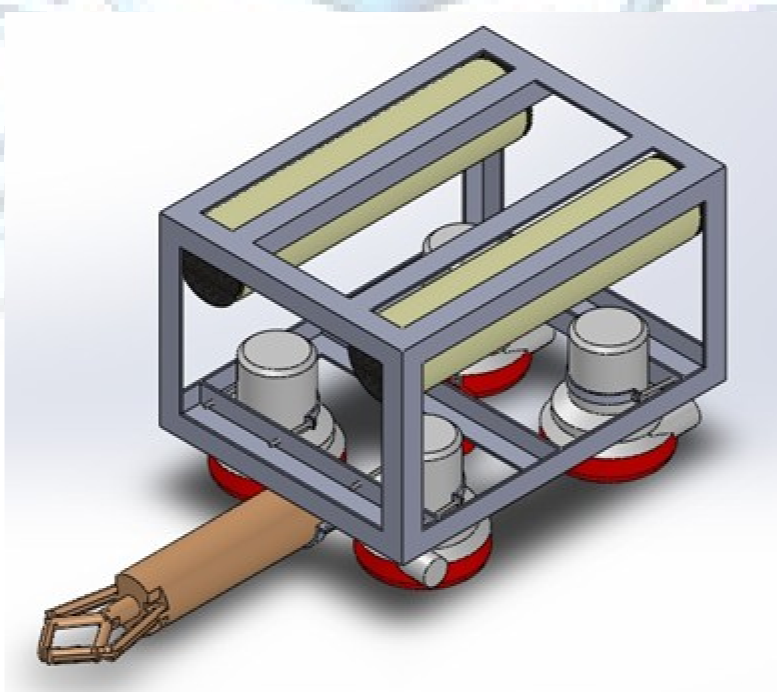


4. Software Block-Diagram

The software part of the system is used to calculate the shipwreck length as well as its orientation with respect to the grid. The operation is very simple, as the co-pilot capture an elevation view from a camera and then the user is selecting points on the shipwreck and on the grid. According to the scale of the grid, the length of the shipwreck is calculated. Referring to the intersection of the line that connects the steam to the rear of the shipwreck and the grid line, the orientation of the shipwreck is calculated.



5.Design Rationale



5.1 Frame

The frame of ***RECFRS*** is very simple but sturdy and light. It is constructed from aluminum bars (3*3cm with 90° angle between them, 3mm thickness each). ***RECFRS*** frame dimensions are 40cm*30cm*23cm joined together using rivets as shown in Figure 1.

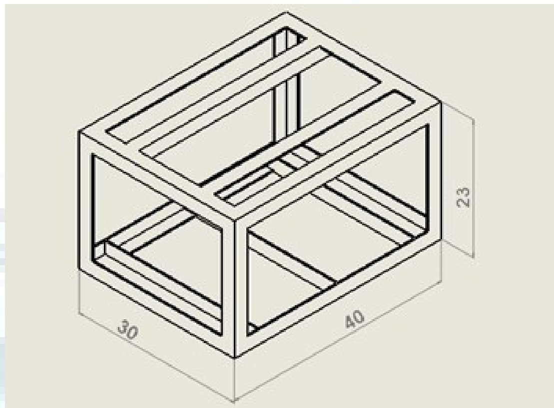


Figure 1. RECFRS ROV Frame Design

The material of the ROV was chosen depending on the depth that the ROV will dive through. The frame has been drawn, stress and displacement analyzed by "SOILDWORKS" to make sure that the frame aluminum bars will not be affected by the pressure of water in the required depth (Figure 2 and Figure 3.)

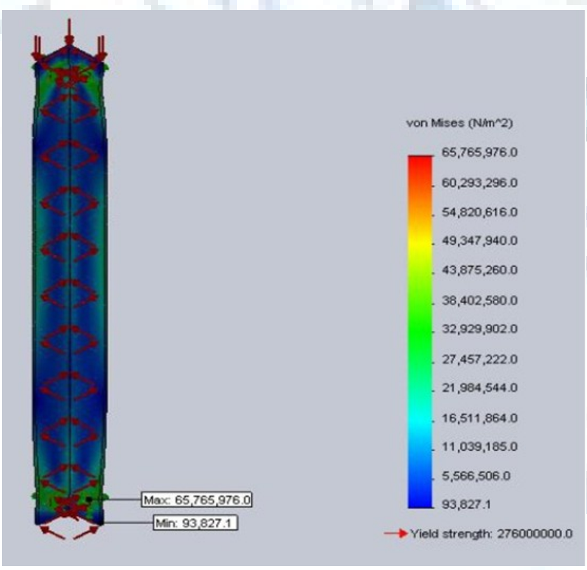


Figure 2. Stress Analysis on Aluminum Bar

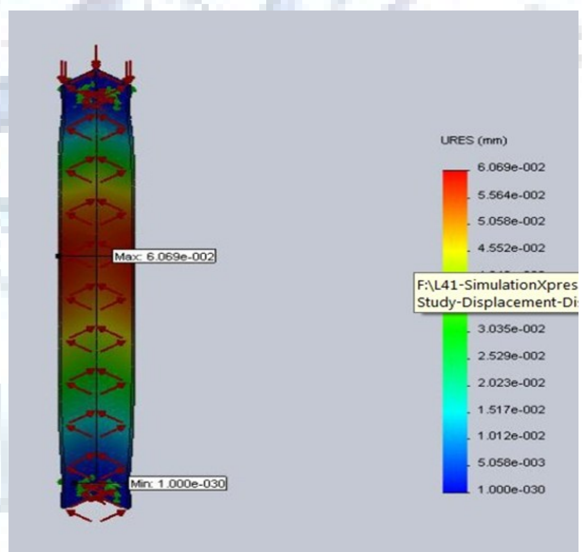


Figure 3. Static Displacement on Aluminum Bar

A Computational Fluid Dynamics (CFD) simulation has been accomplished using "ANSYS" workbench for examining the resisting forces effect (viscous, pressure and lifting forces) on the ROV while it is moving. Stream lines and contours are also simulated using ANSYS (Figure 4).

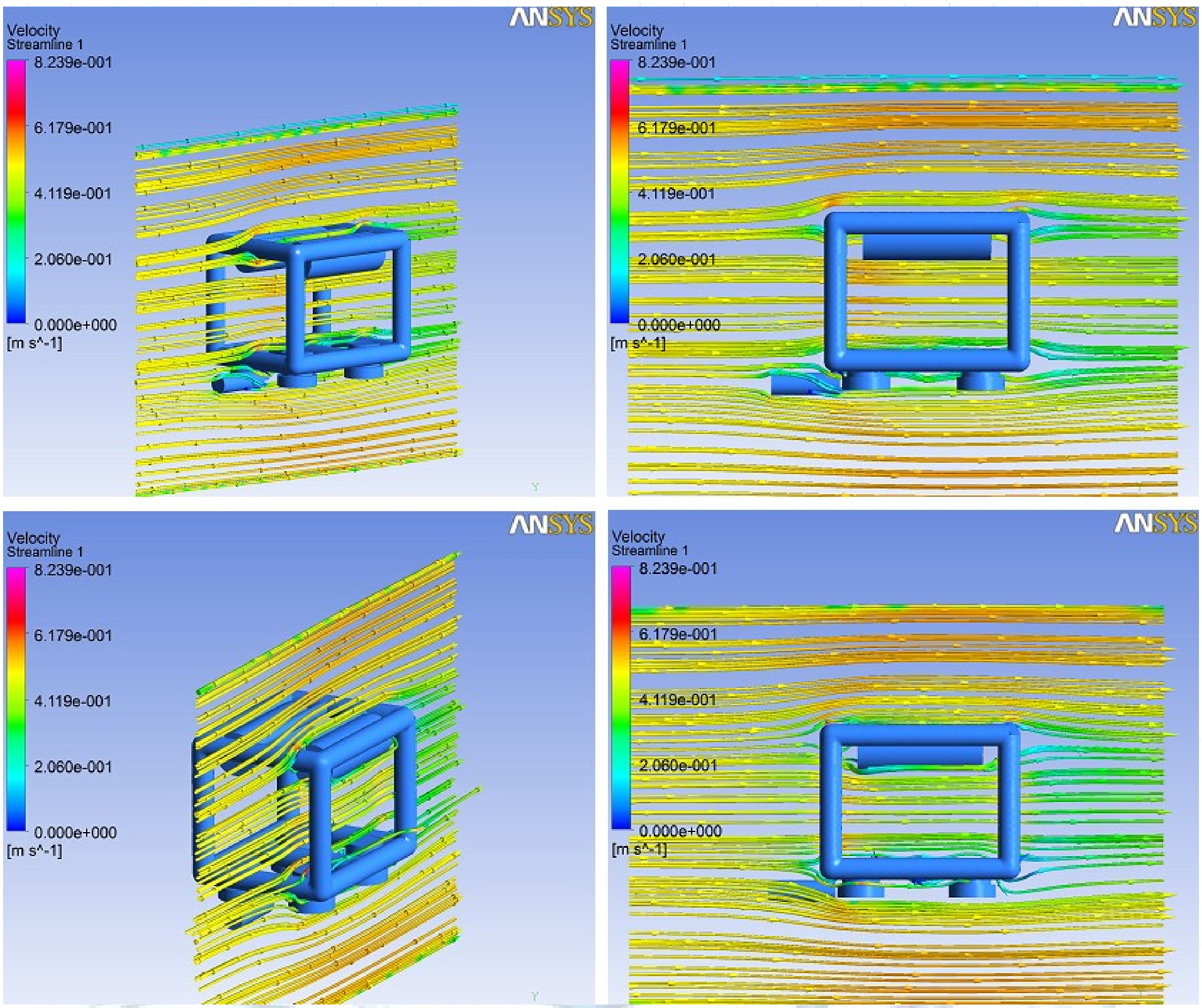


Figure 4. Stream Lines on Some Sections in the ROV

The total force (viscous and drag forces) that affect the body at the speed of 0.5 m/sec (which is the maximum speed of the ROV) is = 36.02 N

The lifting force at 0.5 m/sec is equal = 0.216 N

Pressure that exerted on the ROV = $\rho * g * H$ = 1000 * 9.81 N/m * 5.5m = 53.955 kPa

The entire frame weights= 1.750 kg.

Total volume of the body=648*10^-6 m3

Buoyancy force = Row fluid x Volume of displaced body x Gravitational Force

= 1000 *(648*10^-6) *10 = 6.84 N

The weight of frame = Mass of frame x Gravitational Force = 1.75 x 9.8 = 17.15 N

The net force on the frame= Frame Weight – Buoyancy Force = 17.15 – 6.84 = 10.31 N

So we need up thrust force greater than 10.66N to overcome the weight of the frame on water.

5.2 Thrusters

Bilge pumps are used as thrusters to control the motion of the body. There are four 2000 GPH (Figure 5) pumps for forward, steering and side movements. For backward movement, one 1100 GPH pump (Figure 6) is used and another 1100 GPH has been modified with a propeller for up/down movements.

Figure 5. 2000GPH Bilge pump

Figure 6. 1100GPH Bilge pump

5.3 Circuits Containers

Two PVC 8cm diameter tubes of 40cm in length are used to store controlling circuits of the ROV. They are well isolated with cone-shape rubbers batches. They are used for providing floating force to the ROV as well.

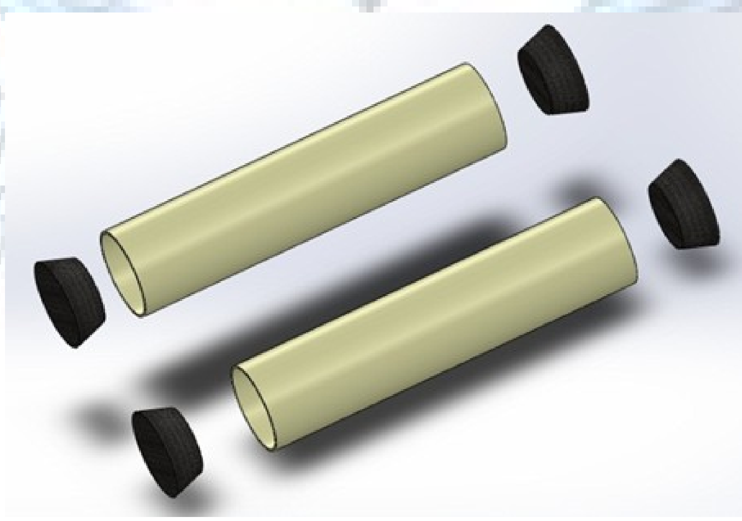


Figure 7.Circuits Containers

5.4 Video System

RECFRS has three video cameras (Figure 8) mounted on board. One fixed to view the horizontal view for navigation and maneuvering, the 2nd camera is mounted for viewing manipulator, proximity sensor and fuel tank in/out ports. The last camera is used calculating the length and the orientation of the shipwreck.

Figure 8.Underwater CCD Camera

5.5 Tether/TCU

The used tether contains

- Three cameras cables (co-axial and power cables).
- Two plastic hoses.
- Power cable.
- Control and low voltages cable (16 wires)

All the cables are held together and isolated using insulating black tape for safety purpose.

5.6 Safety

In ***RECFRS*** Safety is a major concern. Several procedures are taken into mind to ensure that incidents are avoided or minimized as much as possible:

1. Kort nozzle applied on the propeller.
2. 40 amp Circuit Breaker on the main source
3. The 2000GPH bilge pumps have 15 amp Fuse.
4. The 1100GPH bilge pumps have 10 amp Fuse.
5. Warning badges over kort nozzles and control box.
6. Sharp edges were overcome by smoothing them
7. Applying safety procedures while working in lap like wearing safety goggles and safety fuses while working in control boards.

5.7 Patches Holder

Simple mechanism designed to hold two simulated magnetic patches at once and mount them on the in/out ports on the shipwreck hull accurately at the same time.

5.8 Proximity Sensor

For debris detection, an inductive proximity sensor (Figure 9) is mounted on board where switches sense distance to objects by generating magnetic fields. They are similar in principle to metal detectors. A coil of wire is charged with electrical current, and an electronic circuit measures this current. If a metallic part gets close enough to the coil, the current will increase and the proximity switch will open or close accordingly.

Figure 9.Proximity Sensor

5.9 Lights

Waterproof cameras casings are equipped with built-in lights source for both the navigation purpose and the flashing mission.

5.10 In/Out Ports& Fuel Tank System

Hand-pump (Figure 10) is used to get the fuel outside the tank and a small pump to put water instead of the fuel inside the tank. Hoses made of 10mm dia. plastic material are used in this mission.

Figure 10. Hand Pump

5.11 Manipulator

The design of the manipulator (Figure 11) has only one function for simplicity. Having multiple functional manipulator tends to lead to extra cameras, extra weight, and off-vehicle-center mounting of the gripper, which is more challenging for the pilot.

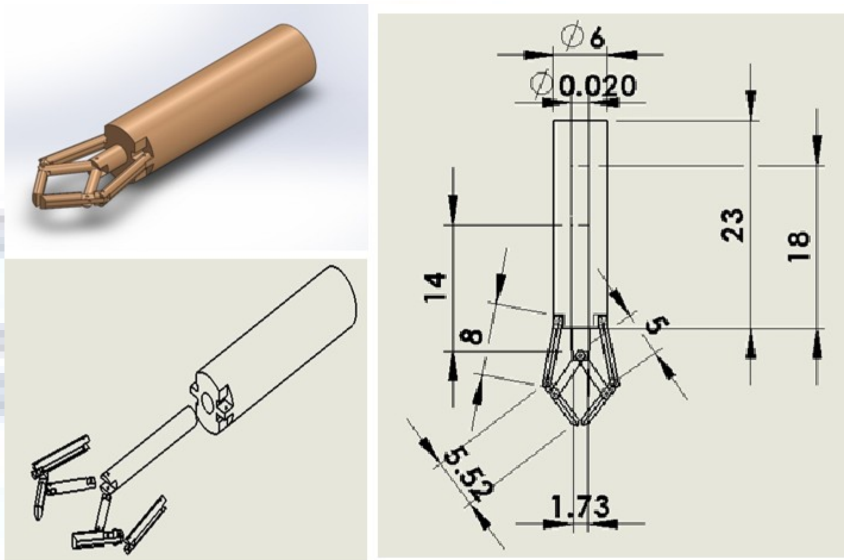


Figure 11.Manipulator Design

5.11.1 Structure

A Plastic material (Artinol) is used to build the arm body and gripper where this material has the strength needed and it can be machined easily.

5.11.2 Gripper Actuation

Manipulator's gripper is actuated using a solenoid (car's center lock unit as shown in Figure 12).

Figure 12. Manipulator Controller

6. Challenges

- Machining the propellers with the demanded dimension as it was not available.
- Reducing the voltage level from 48 to 24, 12, 9 and 5 volts onboard.
- Deliver the required power for each motor without overloading the electronics components used.
- Learning SOLIDWORKS and ANSYS in short time.
- Sealing our circuits on board.

7. Troubleshooting Techniques

To make sure that the ceiled tubes containing the electric circuits are not taking any water on board the ROV a test was carried on where a syringe was inserted into the side of a tube through the rubber and the whole ROV is tilted to its direction and the syringe is pulled so that any water – if present- is removed. After applying this test several times and varying intervals of operation the syringes used did not contain any water …therefore the tubes are considered ceiled.

To check the system’s stability electrically, testes where carried out on the electric boards and bilge pumps-with or without propellers- at all status whether no load, ordinary (expected) load or over load. The current was measured and documented to indicate the limits of the boards circuitry and pumps, to deal with it accordingly.

Maintaining the boards in full function is the primary target, so fuses where to be placed in the circuits to assure the safety of boards and connections (7A) so that if any overload occurs and more current than specified is passing through the boards the fuse disconnects the circuit to insure the safety of all the other components.

8. Lessons and Gained Skills

AAST Team isn't the first time to participate, on this year the team has learned a lot from the last year. The first thing to learn is passing the knowledge to the new team members, using time schedule, getting familiar with using new programs in designing and new working tools, organizing the team members in order to save time and increase working efficiency, introducing new working theme, increasing the sociality between the team members which makes it stronger and communicable. All of these make the team more eligible to overcome working obstacles.

9. Future Improvements

Some modification should be taken into consideration in the future such as improving the body design to achieve more smooth motion referring to ROV's CFD model, improving the end-effector to decrease the load on pilot for precise positioning, also fitting two thrusters in the vertical position to boost movement in the Up/Down movements and to get more degrees of freedom.

10. Reflections on the Experience

The most challenging aspect of the whole build was realizing the designs and calculations we had theoretically with what is to be carried on physically. Where the difference between what is supposed to happen and what actually happens varies vastly, and so extra modifications where held on the spot to avoid any complications.

Managing the tight and busy schedules of all teammates was also one of the main problems faced, to find enough time for meetings and extra brain storming sessions to make sure that all possible solutions to the problem are mentioned and the team chooses one that is most suitable and applicable.

References

The ROV Manual; Butterworth-Heinmann (2007)

Underwater Vehicles; Chris, R.D. and Wernli, R.L. (2007)

Acknowledgements

All of this would not have been possible to happen without the support and tremendous help of the faculty members of the College of Engineering & Technology at AASTMT especially:

Prof. Ismail Abd El-Ghaffar,

Prof. Ossama Ismail,

Prof. MostafaHussain and

Prof. Mahmoud Abo-Zaid.

Appendices

Specifications for the 2000GPH pump:

- Voltage 12 Vdc or 24 Vdc
- Amp Draw 8.4 amp
- Fuse Size 15 amp
- Height 6 inches (152 mm)
- Width 4 1/4 Inches (108 mm)
- Weight 2-15 lb (1.3 kg)

2000GPH Bilge pump

Specifications for the 1100GPH pump:

- Available in 12v & 24v DC
- Amp Draw 3.3 amps (12v)
- Fuse Size 6 amps (12v)
- Height: 108 mm
- Diameter: 61 mm
- Weight: 280g

1100GPH Bilge pump

- CCD Underwater camera
- B/W or color image
- Underwater camera with 15 m cable
- 3.6mm M12 Lens
- Viewing distance in the water: 3-5M
- Operating Voltage: 12V DC

Underwater CCD Camera

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