Maritime State University Robotics Team

Team composition:

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Nikita Sapsai – programmer
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George Sobyanin – designer
Sidelnikov Sergey – designer
Kirill Kondrashkin – designer
Viktor Stadnikov – electronics engineer
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Team organization

We are located in a picturesque place, in the Primorsky Kray, Vladivostok, on the very shore of the Sea of Japan. Our team has a clear division into the following roles: designer, programmer, electronics engineer. The student takes on a role depending on the competencies that he possesses. Students are guided by their own experience, knowledge from the Internet, as well as the ROV of experienced mentors who control the process of building the device, give advice on any questions that a student may have, and take part in coordinating the entire project. Team meetings are held every week in a specially equipped robotics lab, while each team member shares their progress from the previous week, discusses future tasks and missions, and assigns tasks for the next week, the entire workflow is built on Agile development methodology. Management and planning of the workflow is carried out through team meetings and personal meetings between team members and mentors, as well as online in a general social networking conference. Documents and materials necessary for teamwork are transferred to each student. An important characteristic of our team is that the mentors who support students in the process of developing the ROV were former team members themselves, thanks to which they have not only the necessary technical knowledge, but also invaluable experience in creating ROV, understanding the structure and essence of teamwork. in the project, which, of course, is very important for the training and education of new team members.

Annotation

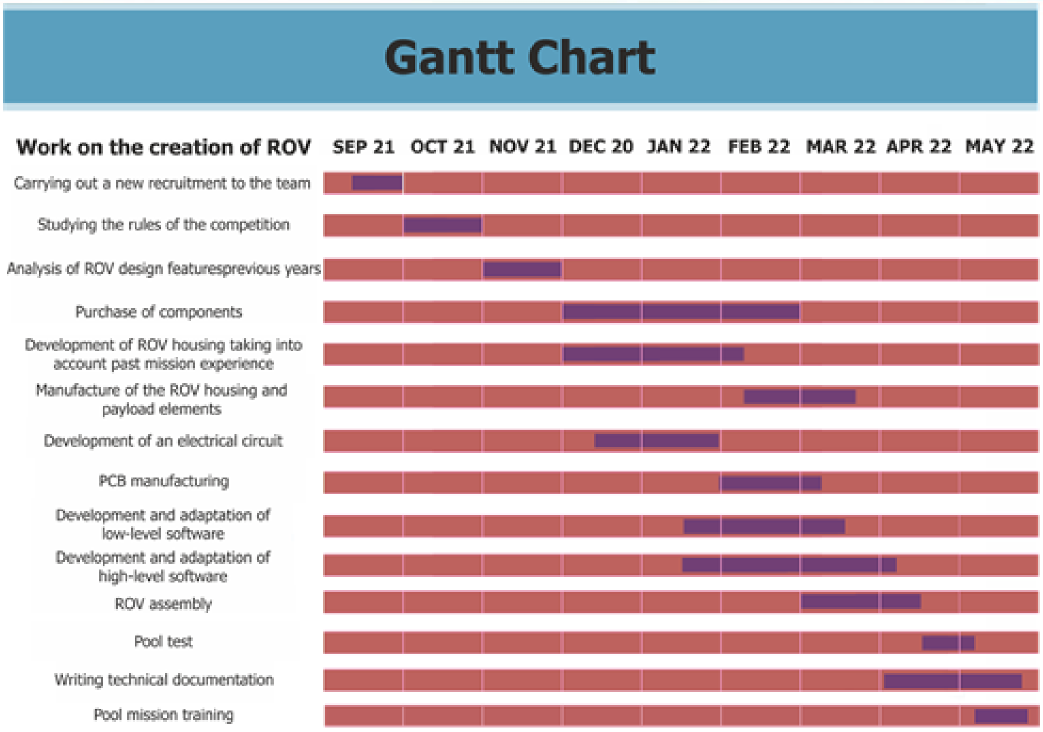
Our team consists of 12 people, each member of the team is assigned his duties, while we help each other to eliminate various gaps in knowledge and competencies, mentors actively monitor and help in difficult situations. We are a very close-knit team and support each other in all aspects. The ROV that we have developed and assembled is fully adapted to fulfill the tasks set this year thanks to design solutions, software and the quality of the materials used, each decision was made with an eye to the tasks set this year. We also found a compromise in many decisions, since it is impossible to implement all the ideas thought up during the brainstorming, but you can choose the best options from them that will help you achieve the desired result. Each member of the team contributed to the final version of the device, someone to its design, someone to the software part, someone to the electronic component, but only as a result of common efforts did we manage to create a device with which we can compete. The device is completely safe both for people operating it and for the environment.

Picture 1 "Working days in our team"

Payload

Table 1

Task 1	
Subtask	Payload
Search for a damaged pipe	Camera
Removing rods	The main manipulator
Pipe replacement	The main manipulator
Fixing the pipe	The main manipulator
Replacing the Velcro Attachment	The main manipulator
Underwater buoy installation	The main manipulator
Removing the mesh	The main manipulator
Task 2	
Search for debris and damaged sections of the grid	Mission software
Repairing damaged areas	The main manipulator
Garbage collection	The main manipulator
Removing rods	The main manipulator
Search for dead fish	Mission software
Cleaning up dead fish	The main manipulator
Measuring the length of mock fish	Mission software
Measuring the weight of mock fish	Mission software
Algae cleaning	The main manipulator
Algae Planting	The main manipulator
Task 3	
Float installation	The main manipulator
Inspection of the shipwreck	Mission software
Mapping	Mission software
Measuring the length of the wreck	Mission software



Picture 2 "Gantt Chart

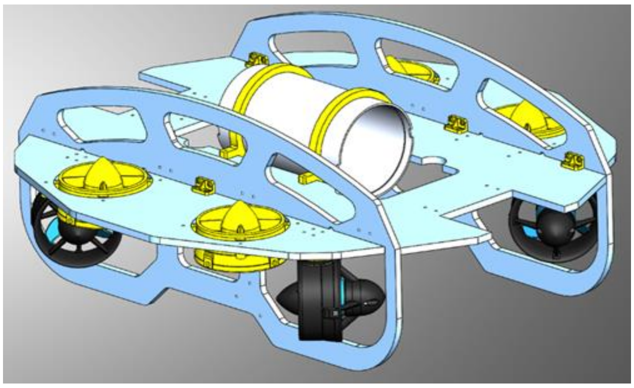
Design Process

The main goal of our team, which has mastered our minds and hearts, is the successful completion of all missions (although honestly this is a bit utopian), for this we carefully studied all the missions, from goals to materials from which models are built, all this was difficult and tiring for the team, but this path had to be done to achieve the cherished goal, thanks to this we had a complete understanding of what the final result should be. After a tedious analysis of the missions, and discussion of the strategy for their implementation, we started designing, during the development of the design, as well as the internal and external device of the ROW, we had lively discussions and debates, each member of the team was directly involved, suggested, criticized, and defended the solutions each other, in such heated debates, a single concept of the ROW was born from us: good controllability became the key characteristics - which is achieved by a well-thought-out design of the ROV. The design of the ROV has a low resistance to water flow, due to the large number of technological windows. This was achieved thanks to the advanced SolidWorks CAD system, which made it possible to simplify the development of the , reduce the final cost of the ROW and select environmentally friendly materials for the construction of the ROW. Another not unimportant goal was to make it convenient to work with the electronics of the ROW, since we had experience with previous ROW, we applied this knowledge in order to minimize the number of possible malfunctions and their convenient correction in case of occurrence, prompt and convenient changes and improvements.

Design change during development

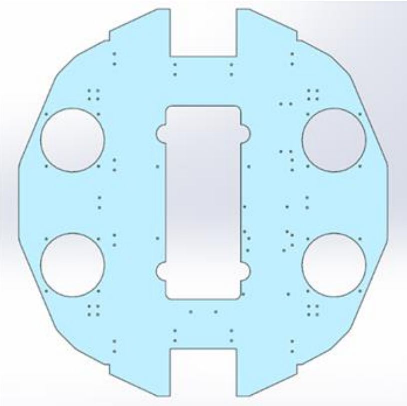
As with any project, ours did not take its final shape right away. Although the main elements were discussed and agreed upon by us at the very beginning, some of them, nevertheless, changed during the design. So, for example, a flask. We considered different materials and sizes, but in the end, after weighing all the pros and cons, such as ease of access to electronics, compactness and the amount of materials needed, we came to the current version with an aluminum flask, as the most suitable for us. We also increased the length of the cable, as it turned out during testing that from past operating experience it turned out that its length was not enough for tasks at a great distance from the coast station. So at the last competitions we faced this problem, when the cable was almost tight with the control panel, which was not safe. Despite the fact that the main layout of the ROV was developed at the first stage of design, during the assembly process, its configuration underwent certain changes due to the identified need to increase the efficiency of the required missions. When developing the ROV, it was decided to link the equipment on one plate. A ROV with this design can be simply assembled and disassembled in malfunctions. This design provides unhindered access to the payload element without dismantling the hull.

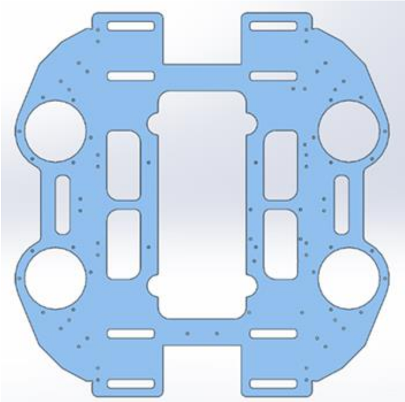
A test floating version was assembled without a payload Picture 3.



Picture 3 "The model of the ROV without payload"

During the test swims of the apparatus, a problem was identified. Such a large hull plate created strong water resistance. The craft was lagging when a dive or ascent was required. Therefore, it was decided to remake the hull. The problem that the case was too large and uncomfortable was fixed. Cutouts have been added to reduce water resistance. Now the hull requires less material, the hull has become lighter and no longer interferes with ascent or descent Picture 4 and 5.





Picture 4 "Old Plate" *Picture 5 "New Plate"*

Propulsion steering complex

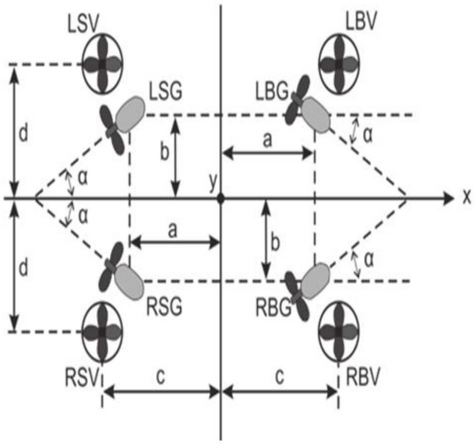
Our submersible is equipped with 8 brushless propellers: 4 vertical and 4 horizontal, located according to the vector scheme at an angle of 45 degrees (according to the Falcon scheme). This type of location provides high maneuverability of the vehicle and the stability of its angular position in roll and trim, which is one of the key guarantees for the successful completion of the corresponding missions. Propellers are an assembly consisting of the following elements: three-phase brushless motors placed in a sealed streamlined housing; three-phase motor driver; case-screw system.

The main characteristics of the used propellers are presented in Table 2.

Table 2

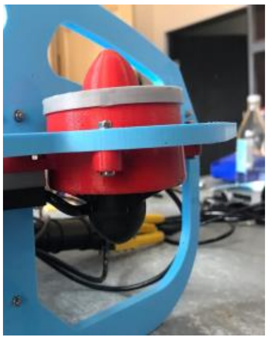
Options	Values
Kv	350
thrust	2 kg
Working voltage	12-24 V
MAX. current consumption	10 A
ESC	30 A
MAX. turns	5600 rpm.

The selected layout of the propulsion-steering complex provides controllability of the vehicle in six coordinates - stroke, log, depth, heading, roll and trim Picture 6.



Picture 6 "Layout diagram"

The voltage at 19V is taken from two DC/DC converters. To increase the efficiency of the propellers, the propellers are placed in hydrodynamic nozzles made of PLA plastic using 3D printing (hbc/ 2-4). To ensure the safety of the ROV operators and the diving group, as well as to exclude the possibility of various debris and elements of marine networks getting on the rotating blades, special protective nozzles were made and installed on the casings of the propellers. The filling area was chosen based on the criteria for ensuring the required level of safety and maintaining the traction characteristics of the vehicle.

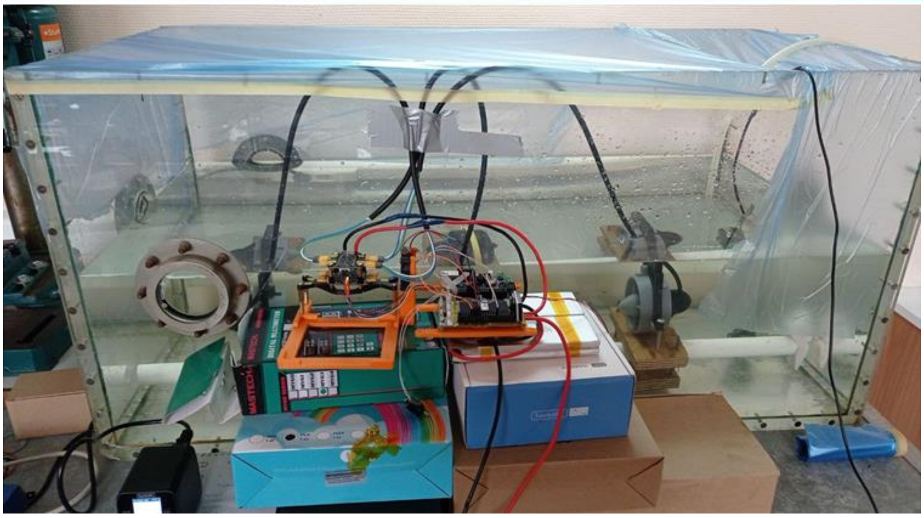


Picture 7 "Propulsion mount"

Picture 8 "Fastening and protection"

Picture 9 "Security testing"

The advantage of using elements made using 3D printing is the ability to quickly manufacture and replace components in case of damage or modernization.

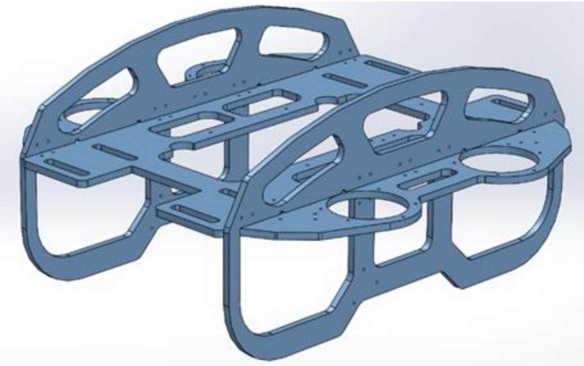


Picture 10 "Test stand"

A laboratory test site was assembled for testing Picture 10 in the form of an aquarium with a volume of 0.47 m 3, in which we tested the developed propulsion and steering complex . As a result, the optimal settings and parameters of the system under test were selected.

Frame and buoyancy

When developing the carrier frame, special attention was paid to its weight and size characteristics, ease of maintenance and lightness of construction. Based on the specified criteria, the load-bearing frame structure was designed in the SolidWorks computer-aided design software package Picture 11.

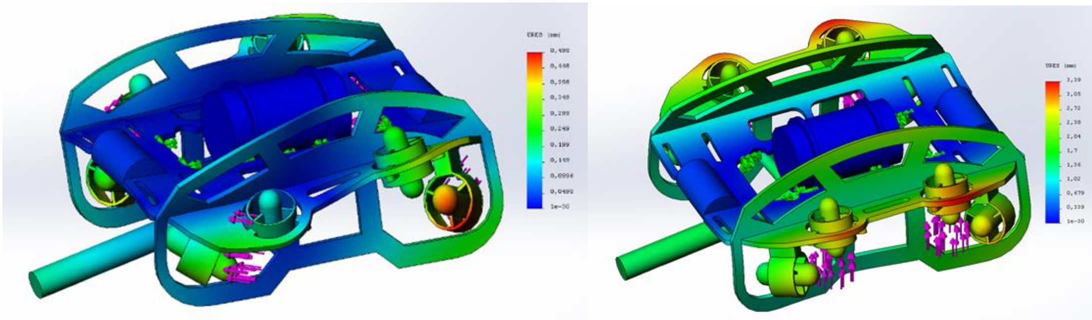


Picture 11 "ROV load-bearing frame"

The developed shape of the body provides rational placement of all elements and systems of ROVs, and also provides easy access to all components of the device in case of need for repair work or replacement of components. The body of the ROV consists of a main flat horizontal plate 620x620 mm in size with cut out holes for attaching the payload and two supporting flat plates 258x548 mm in size. The frame has been designed to meet the following requirements:

- missions to be completed by ROV;
- payload;
- number of propellers and their layout.

Additional structural rigidity is provided by a horizontal strut made on a 3D printer, which simultaneously acts as a fastener for the manipulator. The distribution of payload modules is implemented in such a way as to ensure a minimum shift in the center of gravity of a fully equipped ROV compared to the center of gravity of the assembled frame. This approach subsequently greatly simplified the process of balancing the apparatus during testing in water. The shape of the horizontal platform, as well as the design of the hermetic flask, make it relatively easy to integrate additional payload modules on this underwater vehicle, if necessary. To minimize the weight and size characteristics of the developed apparatus, a polypropylene sheet with a density of about 980 kg/m3 was used as the material of the supporting frame. Initially it was supposed to use sheets with a thickness of 10 mm. But in order to reduce the total weight of the finished complex, we decided to conduct a computer simulation of the load distribution in the case of using a starting material with a thickness of 8 mm. The simulation result is shown in Picture 12. According to the obtained distribution, the use of 8 mm thick polypropylene as the frame material will not lead to deformation of the carrier plate and a significant decrease in the strength characteristics of the finished case.



Picture 12 "Load distribution simulation"

The frame was manufactured by CNC milling, which achieved high precision overall dimensions of the finished body parts. During the milling work, all necessary safety measures were observed, such as the use of appropriate personal protective equipment, milling only on correctly operating equipment using serviceable tools, etc. For the manufacture of the buoyancy of the apparatus, the following materials were initially considered:

- Styrofoam;
- polystyrene foam PS-1-350;
- polystyrene foam extruded;
- polystyrene foam polyurethane foam.

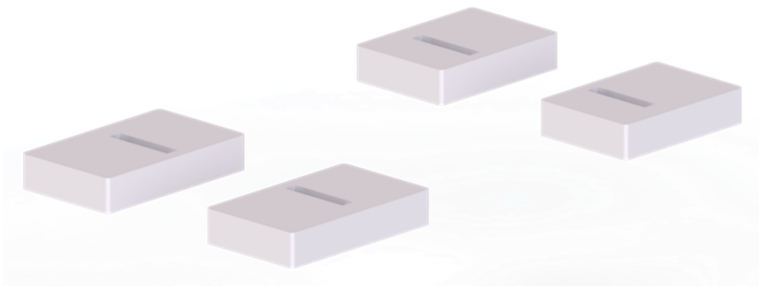
The characteristics of the considered materials are presented in Table 3.

Table 3

Material	Density, kg/m^3	water absorption, %	Compressive strength, MPa	Peculiarities
Styrofoam	15 – 25	2	0.05-0.2	Pros: low cost, low density Cons:brittle, high water absorption coefficient
Polystyrene foam PS-1-350	300-400	<0.5	6.9	Pros:high strength characteristics, the most suitable material for machining

extruded polystyrene foam	30- 40	≤0.2	0.25-0.5	Pros: low cost, low water absorption coefficient Cons: poor wear resistance, flammability, sensitive to ultraviolet
expanded polyurethane foam	40-80	≤0,1	0.31	Pros: elasticity, wear resistance, non-flammable Cons: relatively high cost

Initially, it was decided to manufacture the buoyancy of the underwater vehicle from polystyrene foam PS-1-350 due to its high strength characteristics, low water absorption coefficient and the possibility of relatively simple subsequent machining to give the desired shape to the final product. But as a result, we faced the difficulty of purchasing this material, which consisted in the absence of offers on the market for the sale of small volumes of PS-1-350 (the minimum volume of the purchase lot was from 1 m3). In this situation, the final choice fell on the purchase of extruded polystyrene foam because of its most optimal ratio of price and required characteristics. The analysis of the assembly of the device with the payload showed the need to manufacture buoyancy with a total volume of about 1202*10-6 m 3 . As a result, this volume was distributed between 4 separate elements, which were installed on a horizontal carrier plate. Buoyancy is shown in picture 13.



Picture 13 "Buoyancy"

Electronics housing

The electronics housing is designed to accommodate the main electronic components of the ROV. The electronics unit has a cylindrical shape with a height of 18.2 cm and a diameter of 10.8 cm. Anodized aluminum was chosen as the material due to its resistance to corrosion, sufficient strength, high resistance to compression and optimal thermal conductivity for efficient heat removal to the external environment. In order to increase heat dissipation with the help of a CNC milling machine, radiators were additionally made, the contact pad of which corresponded to the inner radius of the bulb curvature and installed in direct contact with DC-DC converters.

The case is located in the center of the device and has two covers in one, of which there are 6 holes, and in the other 8 Picture 14. Epoxy is used as a sealant because it performs well, is easy to apply, and has low shrinkage on cooling. For sealing caps, our team uses Picture 15 rubber torics, which are lubricated with Picture 16 to ensure maximum sealing, a better fit of the rubber bands, mechanical seal, and also to prevent drying. The case itself is attached to the ROW with the help of half rings, which are pulled together from different sides with the help of bolts. Of the cases, there are also 2 flasks for cameras Picture12, one of which will be frontal, and the other manipulator. The flasks themselves are 8.9 cm high and 6 cm in diameter. The chamber flasks are made of acrylic glass and the lids are aluminum. Acrylic was chosen because it has high light transmission, strength, is also quite light, resistant to moisture, easy to cut and has electrical insulating properties.

Picture 14 "Camera cover"

Picture 15 "A flask with a camera"

Picture 16 "Sealing gel"

Electronics

The design of electronics for remotely controlled underwater vehicles (ROVs) is a complex task and has a number of features that depend on the purpose of the vehicle, operating depth, and installed payload. The choice of suitable electronic components is the key to the stable operation of the submersible. Based on the experience of using various technical solutions and components, we have chosen the optimal electronic layout of the underwater vehicle for this year's tasks.

The electronic part of the underwater complex consists of 3 subsystems:

- The lower level control system, which includes a control controller, a set of sensors and a video system installed inside the vehicle and protected by a sealed housing.
- The second system is a power unit consisting of propulsors, speed controllers and a manipulator.
- Which consists of a power supply, current protection, measuring equipment, a router for creating an access point and connecting to a control computer.

An Arduino Mega 2560 is used as a control controller, and an Ethernet shield based on the w5100 chip that implements the physical layer of the Ethernet interface is used to organize communication with the surface. Two-way communication with the device is carried out using a twisted pair - a symmetrical communication line that provides good noise immunity due to twisting the insulated conductors together. After receiving data from the shore console, the controller unit issues control signals to peripheral devices (ESC, drive drivers) and collects data from sensors, forming a response packet. The video system consists of two analog FPV cameras . Due to the fact that there are only two wired channels for video transmission (2 pairs of LAN cables), a switching device was used - a multiplexer, thanks to which you can connect to one channel up to 4 cameras.

For depth measurement and realization of the automatic depth stabilization function the absolute pressure sensor MS5803-30BA was used, which has the following characteristics:

- Measuring range: 0 to 30 bar

- Accuracy of measurement: 0.2mbar

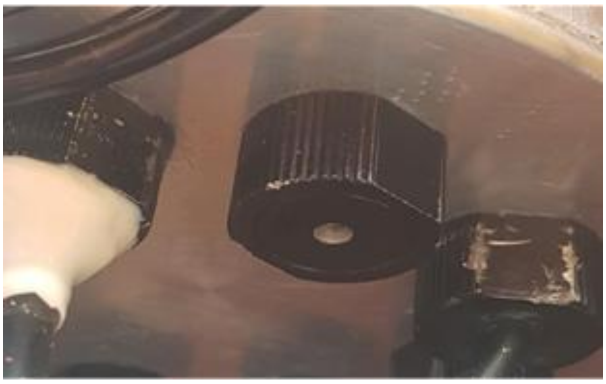
Sensor data processing and filtering is also performed on the onboard microcontroller. For most missions, a depth stabilization feature has been developed that automatically locks the ROV in the operating zone and allows the pilot to avoid being distracted by manual depth stabilization.

The leakage sensor is based on a comparator. When water hits the sensor, the contact closes, an electrical impulse is applied to the comparator and it gives out a logical unit, and if there is no moisture inside the case, then logical 0.

When developing underwater vehicle electronics, it is important to take into account that power electronics, computing modules and video system are powered by the same current source, and therefore are subject to mutual interference that occurs during operation. To reduce the influence of interference, stabilizers with built-in power filters were used. And for an analog video system, galvanic power isolation is provided to form a separate "ground" relative to which the video signal will propagate.

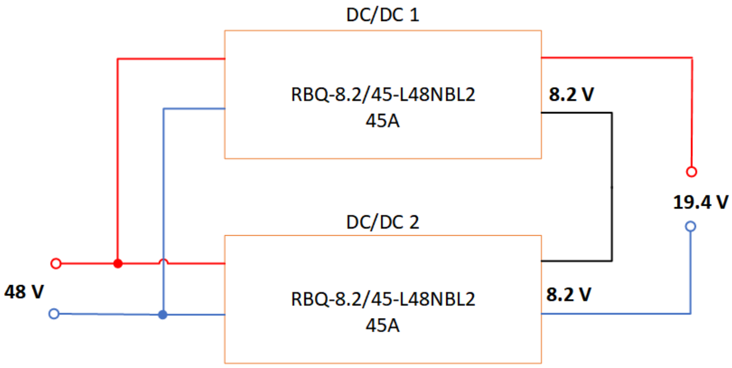
The operating voltage of the ROV is 48 Volts, it is supplied to the device via a silicone, multi-core, power cable with a cross section of 2.5 mm, the current limit is 30 Amperes. A fuse is used to prevent the current consumption from exceeding the permissible limits.

Picture 17 "Electronics assembly"

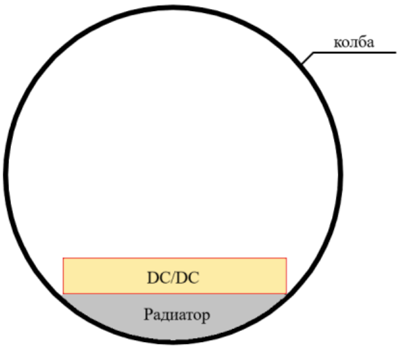


Picture 18 "Depth sensor"

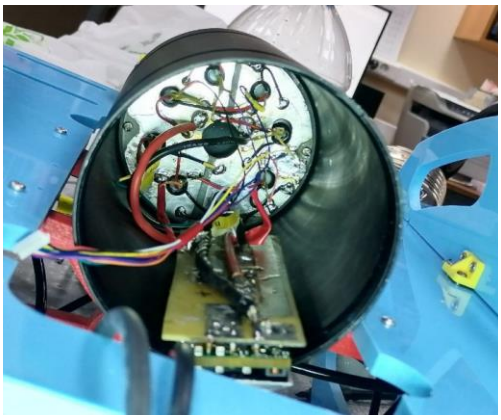
We also used 2 DC / DC converters in order to supply the propulsors with a voltage of 19.4V, since this is the value that is needed to maximize the potential of propulsors that do not have enough voltage of 8.2V to reach the nominal speed, so we decided to connect the converters in series to obtain the required operating voltage.



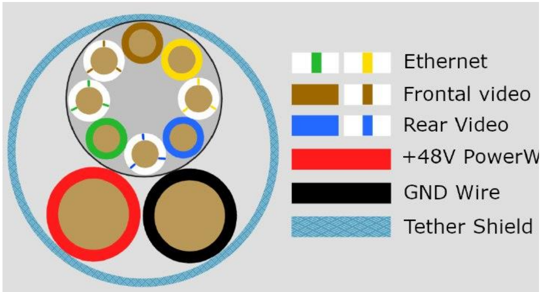
Picture 19 "Connection diagram DC/DC"



Picture 20 "Placement scheme"



Picture 21 "DC/DC location in the bulb"



Picture 22 "ROV cable"

ROV software

ROV software is built around the following nodes: Rov class.

Performs the functions of a control node, initialized with the following directives:

- Data exchange with the propulsion control subsystem;
- Data exchange with the sensor control subsystem;
- Data exchange with the GUI subsystem;
- Data exchange with the data storage subsystem;
- UdpConnection class.

This node provides communication with the upper software level (RovUI), data transfer between communicating objects, acts as a data server for local storage (class RovDataStore).

ThrusterControlSystem class: This node represents the interface between RovUI and ROV payload objects. As one of the members, this class stores all payload objects as an array of objects of type PayloadTool. Objects are managed by calling the update method (writing to the device), and saving (writing from the device).

SensorContainer class: This node encapsulates the operation of sensors, such as a voltmeter, ammeter, pressure sensor, etc. It allows you to receive complex data arrays processed by executing nodes, such as ThrusterControlSystem with a delay of one initialization cycle, which allows you to control the device with high accuracy.

Sensor class: It is the parent class for all objects initialized with any sensors.

PayloadTool class: Is the parent class of all objects for all objects initialized with payload elements (cameras, manipulator).

RovMagics.h file. The file contains configuration constants for all I/O devices. Contains specific constants necessary for the operation of objects. The file contains the number of objects for which memory needs to be allocated.

Mission Specific Tools

Manipulator

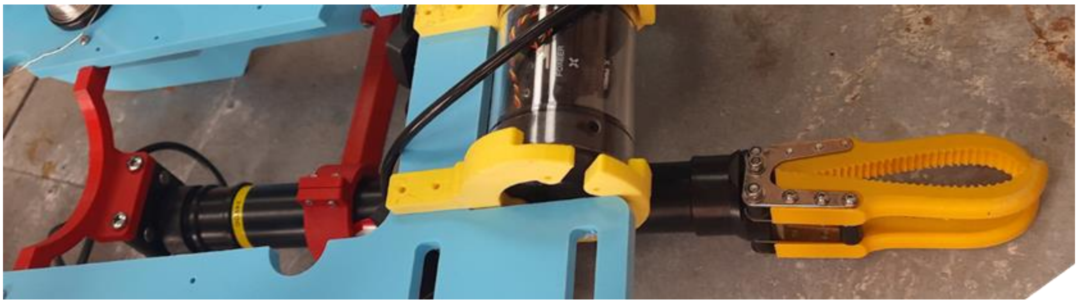
To perform missions related to the movement of objects under water, a manipulator was installed on the vehicle, the characteristics of which are presented in Table 4.

Table 4 "Characteristics of manipulators"

Parameter name	Parameter value
Number of degrees of freedom	2
Rotation angle 1st degree (grip rotation)	360⁰
Angle of rotation 2 degrees (grip opening)	от 0 до 120⁰
Grip opening size	от 0 до 100 mm
Grip grip force	до 100 Н
Manipulator mass in air	1.2 kg
Напряжение питания	24 V
Required power (for operation with two stages at the same time)	5 Vt
Control Interface	0/1
Manufacturer	RovBuilder

As practice has shown in the course of testing the device, the initially chosen placement of the manipulator did not allow capturing some objects. As a result, the placement of the manipulator was chosen at an angle of 8 degrees relative to the carrier horizontal plate with an offset of 10 cm relative to the front plane of the frame. Together, the chosen placement of the cameras and the manipulator made it possible to provide the most optimal viewing angle, which ensured the maximum efficiency of underwater work. The manipulator is attached to the body of the ROV with the help of special clamps and fastening struts. The clamps and mounting spacers were made by 3D printing, which made it possible to achieve the required rigidity of the structure and not significantly increase the total weight of the assembled ROW.

Picture 23 "Capture of the manipulator"



Picture 24 "Manipulator on the ROV"

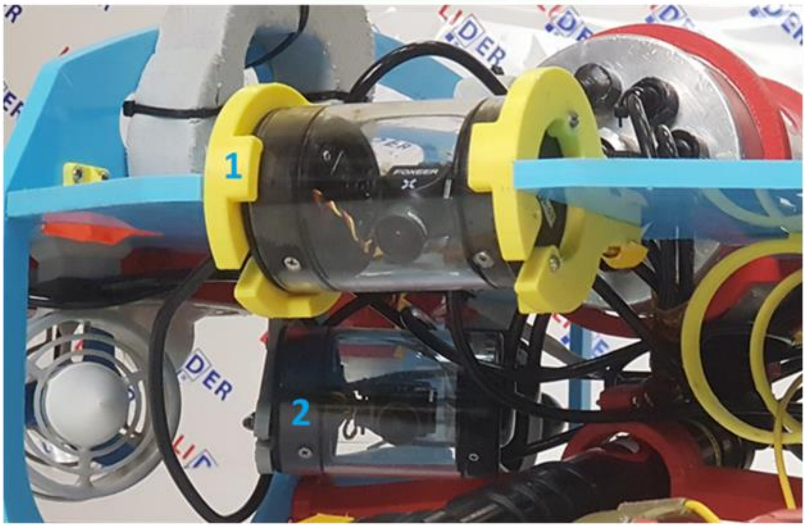
Camera

To enable visual monitoring of the underwater situation, we installed two video cameras of the Foxeer 16: 9 1200TVL Monster Mini Pro model on the ROV, the technical characteristics of the cameras are presented in Table 5

Table 5 "Camera Characteristics"

Permission	**1200 TVL**
Matrix	1/2.9 CMOS 16/9 3DNR WDR
Light sensitivity	0.001 LUX
Chipset	Nextchip 2040 DSP
Input voltage	DC 5V ~ 40V
Consumption current	90 mAh
Viewing angle	~ 160°
Lens	1.8 mm
Signal to noise ratio	more 50dB
Working temperature	-10 - +50 ° C
Dimensions	21.8 x 21.8mm
The weight	12 g

To ensure an optimal field of view during various missions, it was decided to make the following camera layout Picture 25.



Picture 25 "Cameras on the ROV"

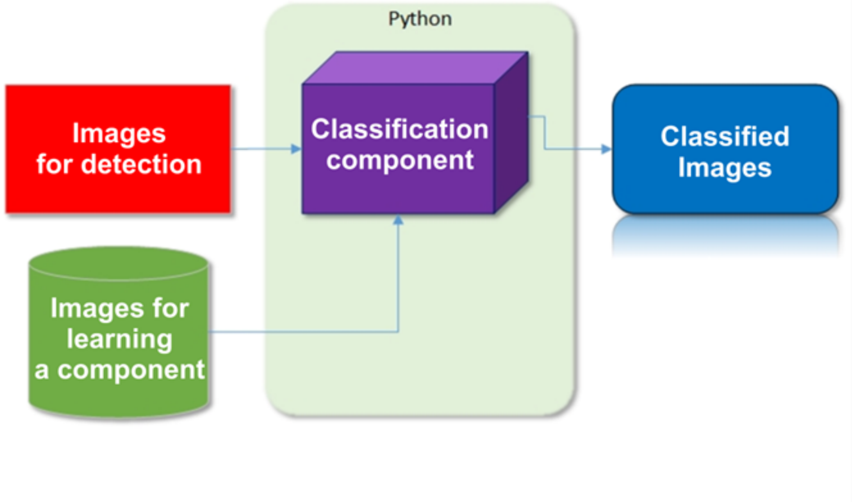
The image is displayed on two monitors of the shore control panel. The upper camera 1 is intended for general visual monitoring of the process of performing competitive missions. The lower camera 2 is designed for a better view when performing tasks related to the precise manipulation of underwater objects (coral replanting, surfacing a sea sponge, setting an eel trap, etc.).

Float principle

For profiling and measuring water parameters at different depths, wecreate a buoy that automatically dives and swims at a speed of 0.4 meters per second.The movement of the buoy occurs due to a change in the volume of the lifting bag due tobuilt-in pump and valve.

Software tool for recognition of dead fish on the undersea

The detection of dead fish at the bottom of marine plantations is a very important task in aquaculture due to the potential deleterious effects of dead fish on the health of healthy fish in aquafarming. When large numbers of decomposing fish accumulate on the bottom, oxygen-free zones can occur. This contributes to the reproduction of bacteria Clostridium botulinum, which release neurotoxin, which is the source of botulism [Yule, Adam M., et al. "Toxicity of Clostridium botulinum type E neurotoxin to Great Lakes fish: implications for avian botulism." Journal of wildlife diseases 42.3 (2006): 479-493.]. Botulism can be dangerous if dead fish end up in a pool under anaerobic conditions. The bacterium can multiply in dead individuals, eating which healthy fish can become infected with the botulism. As a result, the fish die quickly without outward signs of the disease. To avoid this situation it is necessary to detect and eliminate dead fish from the bottom of aquaculture plantations in a timely manner. To solve this problem, we created a software tool that allows automatic analysis of images from ROV video cameras for detection of dead fish. The program was developed in Python. The library of computer vision, image processing and general-purpose numerical algorithms with open-source OpenCV was used to work with images. The neural network architecture YOLOv5 was chosen as the system with the object detection component [Thuan D. "Evolution of yolo algorithm and yolov5: the state-of-the-art object detection algorithm." (2021)] implemented using the PyTorch framework. This architecture can be used on microcomputers with low performance, such as Raspberry Pi 3, which makes it possible to implement the recognition system directly on the ROV without the use of additional CPU devices. Using Deep learning methods, the software tool was trained to analyze images and detect dead fish on the bottom. The structural scheme of the recognition software tool is shown in the Picture 26



Picture 26 "Block diagram of the recognition software tool"

Machine learning was performed on real video data collected during the monitoring of mariculture with ROV. The dataset was generated from about 200 images. When a dead fish is detected, the area in the image is surrounded by a rectangular frame and the detection probability value is displayed.

Picture 27 "A sample of the functioning of the system for recognition of dead fish"

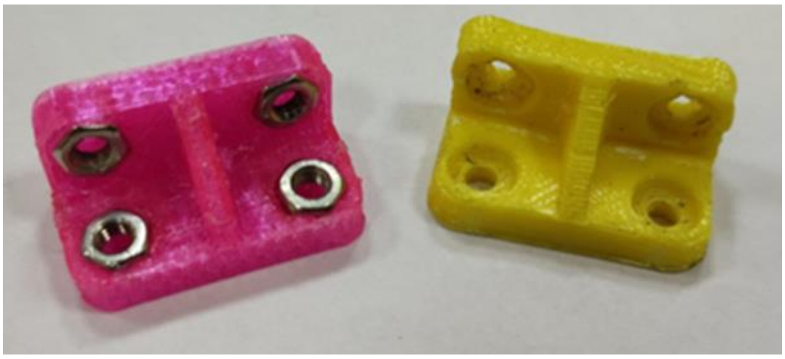
The program shows the chance that the recorded fish is a dead. In this example, the probability of the correct analysis of the image is 0.67, which is interpreted as a reliable result of processing. In the process of training the detection criterion was used, according to which the registration of a dead fish on the bottom of the sea occurs at a probability value equal to more than 0.55. The video that was used to test the finished software component was not used in the Deep learning procedure. The analysis of the finished software product showed that the precision of its correct identification of dead fish was more than 90%.

Methods for eliminating technical malfunctions that have arisen in the process of creating

Our team conducted the troubleshooting process through root cause analysis. Testing of individual components was carried out until the problem was discovered and subsequently eliminated. During the troubleshooting process, team members considered various ways to solve problems before deciding on a final strategy. The main selection criteria were factors such as simplicity, cost, and required execution time. Tests were carried out both in the laboratory test site and directly in the pool. During the debugging, a number of technical problems were identified. So it turned out that the sealing was broken in the cable used. The problem was fixed by its complete replacement, which required a lot of time and effort of all team members. During tests in the pool, it was found that the device leads to the side when moving in a straight line. An analysis of the situation showed that the cause was the uneven thrust of the horizontal propulsion units, because of which they had to be calibrated and partially replaced. The ROV has also been tested in adverse environmental conditions (salty sea water) to simulate the actual operating conditions of the ROW.

This year we had to make the apparatus more powerful than in autumn. Due to the fact that the purchase of new more powerful propulsion units did not fit into our limited budget, we decided to use the old propulsion units, but increase the voltage supply to them, thereby increasing the power. However, we also wanted to replace the rover's cable with a longer one in order to swim to even greater depths and distances. But with an increase in the length of the cable, the resistance in the conductor also increased, which led to a drop in the voltage on the device and, as a result, power loss for the propulsors themselves. We solved this problem by replacing the old DC-DC converters with new, more powerful ones. As a result, this increased the power of the propulsors and made it possible to use them at maximum power without interfering with the cameras, since the cameras themselves are galvanically isolated from the main circuit.

During malfunctions, the device had to be disassembled and reassembled. At the same time, we managed to face the problem that it takes a lot of effort to hold the nut. To do this, it was decided to make cutouts for the nuts so that they do not rotate. This saved a lot of time later on.



Picture 28 "Corner fasteners"

Safety

Team safety philosophy

The safety of employees is the core value and the highest priority of our team. We believe that all team members have the right to a safe working environment and that all accidents are preventable. Our careful preparation and safety procedures allow us to avoid accidents in advance.

Laboratory protocols

Since safety is of the utmost importance, special safety rules apply when working in the laboratory. Before starting any work, each team member receives permission from a mentor who, before giving permission to work, checks that the person is aware of what and how he is going to do, as well as what precautions should be taken before this work. Upon completion of the inspection, if a team member knows his job well and has taken all precautions, he is allowed to work. We use the manual we have written to educate all team members on safety rules: electrical safety, handling of dangerous tools and materials, protection of exposed body parts, housekeeping.

We encourage employee monitoring and the investigation of hazardous incidents. Once a new team member has demonstrated proper working methods, they can work on their own. All team members must constantly supervise each other, making sure that everyone follows the established safety rules.

Machine Security Features

The vehicle contains numerous features designed to keep the ROV, crew, and environment safe during operation. In addition to protecting the electronics with a sealed bulb and the software safety modes described in the previous sections, the thruster motors are covered with mesh and shrouds. Various waterproofing methods ensure that all electronics remain dry, protecting both personnel and equipment from short circuits. Based on a comparator that analyzes the voltage at the sensor contacts, and in the event that water hits the sensor, the comparator triggers and sends a signal to the microcontroller, warning the team to turn off and return to the surface. In the event of a leak, a sensor controlled by one of the Arduinos detects moisture in the electronics cases and alerts the crew to shut down and return to the surface. Our team does not use lasers, pneumatics and hydraulics and our team does not need any certificates to use them. Our machine uses other security features as described above.

Team safety during missions

All missions are completed in the pool. During their implementation, we primarily care about our own safety, so we take appropriate precautions and observe safety precautions while in the pool. Namely: On the territory of the pool itself we move in closed shoes with rubberized soles and in life jackets. Before connecting the device to the power source, using a visual inspection, we make sure that all cables through which current flows from the source to the device do not have bare sections, the power source itself is in good condition and is at a safe level from water. When operating the device in the aquatic environment, the pilots, along with the equipment, are at a safe distance from the edge of the water, and the person who feeds the cable makes sure not to get entangled in it and not fall into the water. When removing the device from the water, we place it at a safe distance from the piloting site so that water from the device does not get on the control panel and power source. If we need to fix such elements on the device itself as propellers, a flask or a manipulator, we first turn off the device and then proceed to the planned actions.

Cable management protocol

Before using the robot, it is necessary to inspect the cable-cable: make sure there are no kinks, no external damage, check the sealing and overall performance.

After the start of work with the robot, the assigned person - the cable manager must monitor the correct feeding of the cable-rope. It should not be tight so as not to interfere with the pilot and avoid possible damage, and it should not be completely in the water so as not to pull the robot to the bottom. It is necessary to feed it so that there are no kinks, and so that the robot does not get entangled in it. At the same time, the cable manager itself must maintain safety precautions. He must wear a special vest, as well as gloves to protect his hands.

After completing the work, it is necessary to re-examine the cable for kinks and external damage.

Reflection

We are just starting to join the work and learn all aspects of developing the case and electronics, as well as writing software for the device. But despite some gaps in knowledge and lack of experience for most of us, we are extremely interested in developing in this direction. Here are the comments of some team members about the time they spent developing the ROW: I'm only in the team for the first year, and before that I did nothing like that, but I liked working on the device as an electronics engineer. Although I don’t have much experience, I want to do this and comprehend all the possible subtleties further. For example, in the future, I would like to better understand the software part of the electronics that I do not have to work with. I am very happy to be able to do robots. © Yaroslav Rakov - electronic engineer.

This is the third year that I have been a member of this team. Robotics gave me the opportunity to develop in many directions. Over the years, I have been in the role of an electronics engineer, designer and pilot. I don't know how my life will turn out in the future and whether it will be connected with robotics, but I'm still glad that at the moment I am part of a team that contributes to the development of underwater robotics and solves problems with environmental pollution. © Sergey Plotnikov - electronics engineer, designer, pilot.

BUDGET

Table 6 "Expenses for the ROV"

Attachments					
Source					
Participants Donated					-
MSU University					$2 970,00
Type	Category	Title	Description	Cost	Total costs
Purchased	Payload	milling machine	Frame manufacturing	$50,00	$50,00
Purchased	Payload	8mm polypropylene sheet	Frame Material	$160,00	$160,00
Purchased	Payload	Analog Cameras	For ROV	$16,67	$33,00
Purchased	Payload	Air pump	For Buoy	$3,00	$3,00
Purchased	Payload	Air valve	For Buoy	$2,30	$3,00
Purchased	Payload	Coupling	For Buoy	$1,52	$1,00
Purchased	Payload	Arduino Nano	For Buoy	$5,80	$6,00
Reused	Propulsion system	Propulsion for the ROV	7 thrusters	$179,00	$1 253,00
Purchased	Propulsion system	Propulsion for the ROV	1 thruster	$179,00	$179,00
Purchased	Autopilot	TE-STM32F407	ROV controller board	$64,00	$64,00
Purchased	Autopilot	Q48SB9R650	DC/DC converter	$12,00	$24,00
Purchased	Autopilot	ROAL Electronics Mod 223E	DC/DC converter	$5,80	$6,00
Purchased	Autopilot	ROAL Electronics Mod 223	DC/DC converter	$5,80	$6,00
Purchased	Autopilot	HWT901B-TTL	Navigation sensor	$97,00	$97,00
Purchased	Autopilot	Housing for electronics	Housing for electronics	$300,00	$300,00
Purchased	Remote Control	Tether	To connect ROV	$204,00	$204,00
Reused	Remote Control	Remote Control	For ROV management	$500,00	$500,00
Reused	Remote Control	Manipulator	For ROV management	$1 250,00	$1 250,00
Purchased	The work of mentors	The work of mentors		$1 836,00	$1 836,00
				Total Donated:	-
				Total Spent:	$5 975,00
			Spent excluding reusable components:		$2 970,00

We evaluated development cost beforehand and knew exactly how much money university would give to us at start of the year. With that knowledge in mind we looked through our old projects and determined what equipment from previous years we could use, also we performed maintenance of cameras and manipulators. These measures allowed us to cut our spendings a bit. Also this year we appointed CFO, who kept records and tabs on our purchases. We didn't have any troubles with purchases and we could acquaire all of the equipment in time.

Self-made VS bought equipment

We bought materials for frame, one proppeller to replace one of the broken ones, bunch of cables and cable braids, and developed new electronics. It was crucial for us that new members of our group learned how to develop themselves, that's why we decided not to use our old electronics unit and developed completely new one. Also we created new profile bouyu and new frame. We made PCB ourselves to cut spendings a bit and to improve student's soldering and development skills.

Self-made VS bought equipment

We carefully consider reusing old equipment since it is more prone to errors and breaking down then newly bought. But if there are some problems with buying new stuff, we simply reuse what we already have. For instance we bought our manipulator 3 years ago and we are still using it.

Conclusion

Non-technical issues

It was not easy to work according to the plan, for various reasons, and there were times when the deadlines for completing assignments were significantly shifted, which led to a rush closer to the competition. Some of the members who have been with us since the beginning of the school year have unfortunately left the team, resulting in an increased workload for other members. After a long period of part-time work, not all students were ready to spend a lot of time in the workshop, which also ultimately affected the effectiveness of the team as a whole.

Acquired skills

At the very beginning of our work, it was difficult, because we did not understand some things that were required of us, but the more we immersed ourselves in the development of the device, the more we understood the role of certain chosen solutions and the changes made, we learned how to work with equipment and software ensuring that we can at least understand the processes by which the ROW operates and can, if not invent a way to improve it, then at least notice the malfunctions in its operation. Many team members got acquainted with new applications for them that allow them to perform their tasks more efficiently and more conveniently.

Gratitude

Our team is grateful to the following individuals and organizations:

- Center for the Development of Robotics
- Dassault systemes - for the SolidWorks product
- G.I. Nevelskoy Maritime State University
- To our parents - for their constant support and understanding
- As well as a senior officer of the EMF MSU adm. G.I. Nevelskoy Boobs S.V. for the time provided for the period of preparation and conduct of the competition
- MATE: We would like to extend our gratitude to MATE Center that has brought us together for achieving a common goal.

Sourse:

https://habr.com/ru/post/423959/

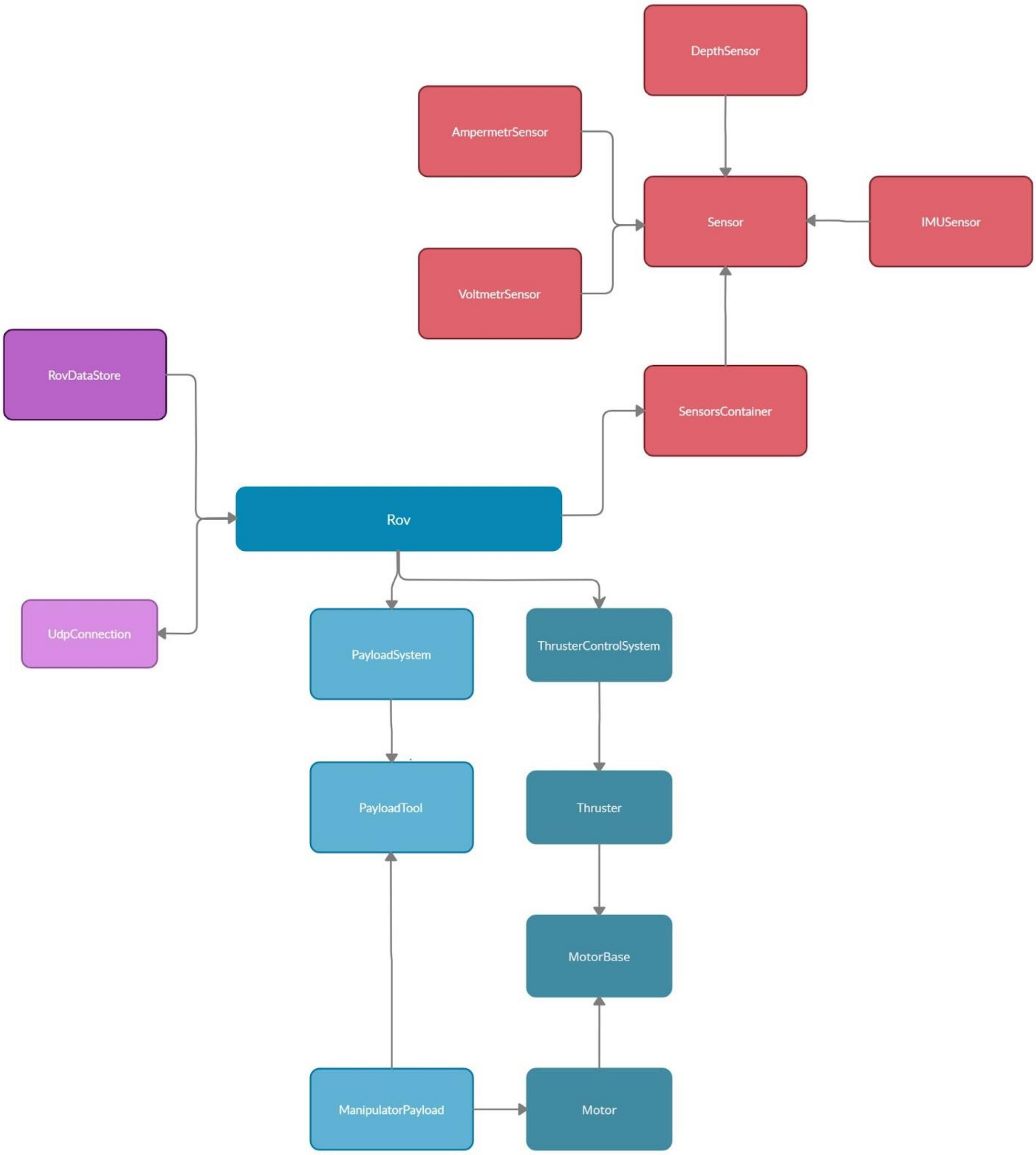
https://files.materovcompetition.org/2022/2022_EXPLORER_Manual_21_JAN_2022.pdf

https://robotrends.ru/robopedia/roboty-dlya-ochistki-okeana-ot-musora

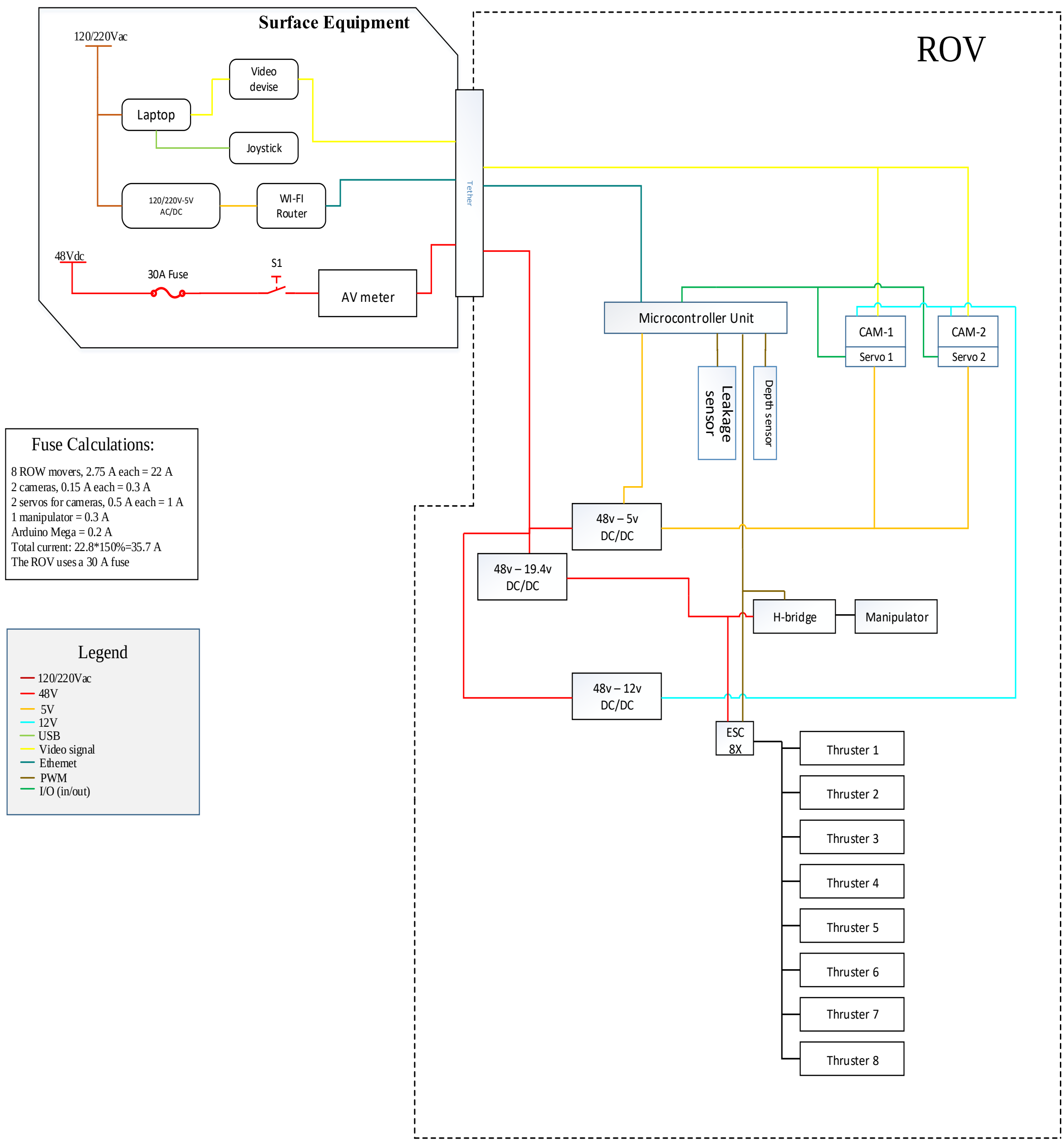
https://robocenter.org/competition/mate-rov-competition/mate-rov-competition-2022/

Applications

Applications1 "Complete architecture of the executing software for ROV"



Applications2 ''System integrated diagram:''



Applications 3"Checklist"

Check before launch	
Checking the fuses	
Checking cables and connectors	
Checking fasteners	
Current and voltage test	
Checking the leakage sensor	
Checking data from ROV sensors	
Checking the correct operation of the cameras	
Checking the correct operation of the propellers	
Checking the correct operation of the manipulator	
Trial run	
Water test	
Checking the leakage sensor	
Checking data from ROV sensors	
Propulsion check	
Current and voltage control	
In the event of a malfunction, disconnect from the power supply and remove from the water	
Job Runtime Check	
Checking the leakage sensor	
Checking data from ROV sensors	
Current and voltage control	
In the event of a malfunction, disconnect from the power supply and remove from the water	
Post-job check	
Checking the frame for external damage	
Checking propulsors for external damage	
Current and voltage test	
Inspection of the electronics housing for external damage	
Moisture assessment inside the electronics housing	
Inspection of cables and connectors	