Admiral Nevelskoy Maritime State University

Maritime State University Robotics Team

Members

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Nikolai Golub - CTO, Manufacturer, Design engineer (Engineering, 2015)
Dmitry Khavshakov - Electronics engineer (Automated control systems, 2016)
Ruslan Starodub - Software engineer (IT security, 2017)

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Vladivostok, Russia

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Abstract

Admiral Nevelskoy Maritime State University Submersible Robotics team is taking part in MATE ROV competitions for the second time. The team was started in November 2013. To have specific tasks in MATE ROV 2015 competitions we have designed and built an absolutely new ROV named «Arctic force». It weighs 26kg, and its dimensions are 750x600x500 mm. our vehicle has a lot of functions: an ability to lift various objects, to measure voltage, to identify stars on the seabed, etc. The ROV was developed by the company stepwise on the basis of the tasks set and challenges faced. The process of the ROV building, testing, final debugging and bringing to full readiness took us 9 months (September 2014 – May 2015). The vehicle's budget in USD is 35,897.

Figure 1. Left to right: Oleg Kozhevnikov, Alexander Morozov, Ruslan Starodub, Alena Sarycheva, Anton Kasatkin, Nikolai Golub, Dmitrii Havshakov, Nikolai Iatcenko

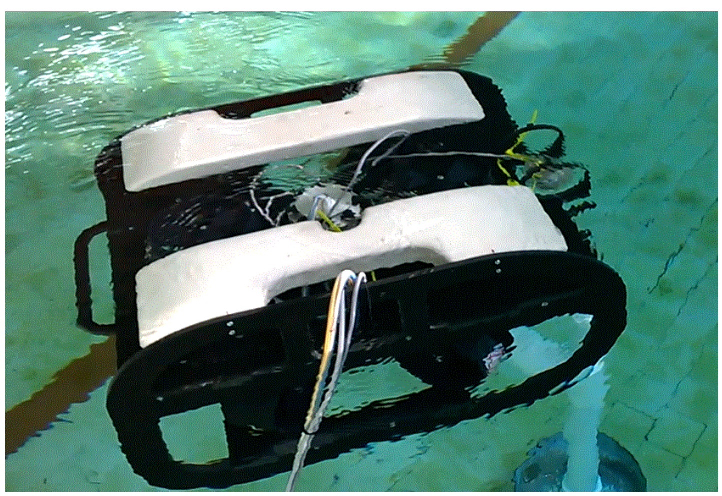


Figure 2. The ROV "Arctic force" in a pool

Budget

Parts and Materials

Item	Donations, USD	Expenditures, USD	Re-used	Provider
ROV				
Surface equipment				
Notebook			700	DNS
TV-tuner			70	DNS
Joystick			70	DNS
TV-monitor			110	DNS
Pelican case		190		Alpha-REK
Mechanics				
Polycarbonate sheet		220		Zenon
Acrylic scheet		35		Zenon
Fittings		240		KIP-Service
Fasteners		100		Marine engineering technology
Materials for housings		140		Marine engineering technology
Materials for props		200		DZL
Electronics				
Microcontroller		140		TerraElectronics
DC-DC converters		390		TerraElectronics
Wires		140		Alpha-REK
Connectors		305		Alpha-REK
Videosystem				
Wide-angle camera		97		SpecVideo
Cameras (135 x 2)			270	SpecVideo

LED		40		TerraElectronics
Pressure sensor		30		Kipaso
Thrusters (1000 x 8)		8000		The Center for Robotics Development
Grabber			1110	RovBuilder
TOTAL FOR ROV		**10267**	**2330**	**12597**
T-Shirts		90		Interface
Trip				
AirTickets (1800 x 6)		10800		Biletur
Visa (200 x 6)		1200		Biletur
Accommodations		4200		Booking.com
TOTAL		**26557**	**2330**	**28887**

Service

Service	Donations, USD	Expenditures, USD	Company
Water jet cutting		250	Advanced cutting technology
Turning and milling services	560		Marine engineering technology
TOTAL FOR ROV	**560**	**250**	**810**

Time

Person	Time, hours
Sergey Mun	200
Denis Mikhailov	220
Igor Pushkarev	100
Nikolai Sergeenko	150
Andrey Kushnerik	80
TOTAL	750

Contributor

Contributors	Amount, USD
Maritime State University	14000
Industry	15000
Student contributions	697
TOTAL	**29697**

Thus, the project’s total budget is **USD29,697**. Cost of the ROV is **USD13,407**.

Design rationale

Technical requirement to the vehicle

Having familiarized ourselves with missions we identified a list of the components needed for the vehicle:

- Frame to accommodate all the other vehicle components is the ROV key part. It consists of vertical and horizontal components. Most of the equipment is mounted on the horizontal ones, while the vertical ones serve for support.
- Buoyancy – a material with lesser density than that of water, at the expense of which the ROV will have positive buoyancy.
- Autopilot to house all the on-board electronics. To protect all the electronics from water the electronics unit is to be made waterproof.
- Propulsion/steering unit, or PSU, comprising electric motors and thrusters. The vehicle has 2 vertical and 4 horizontal thrusters. It is quite enough for comfortable piloting.
- Payload tools:
  - Video cameras (for monitoring the surroundings of the ROV)
  - LED-matrices (required for piloting the vehicle under the conditions of the lack of light)
  - A manipulator (to be capable of grabbing / picking up / turning over an object under water)
  - A pump, a device for turning valves out, a voltage meter on anodized platform legs(for performing the missions)
  - A pressure sensor (to determine the depth, as well as to implement stabilization)

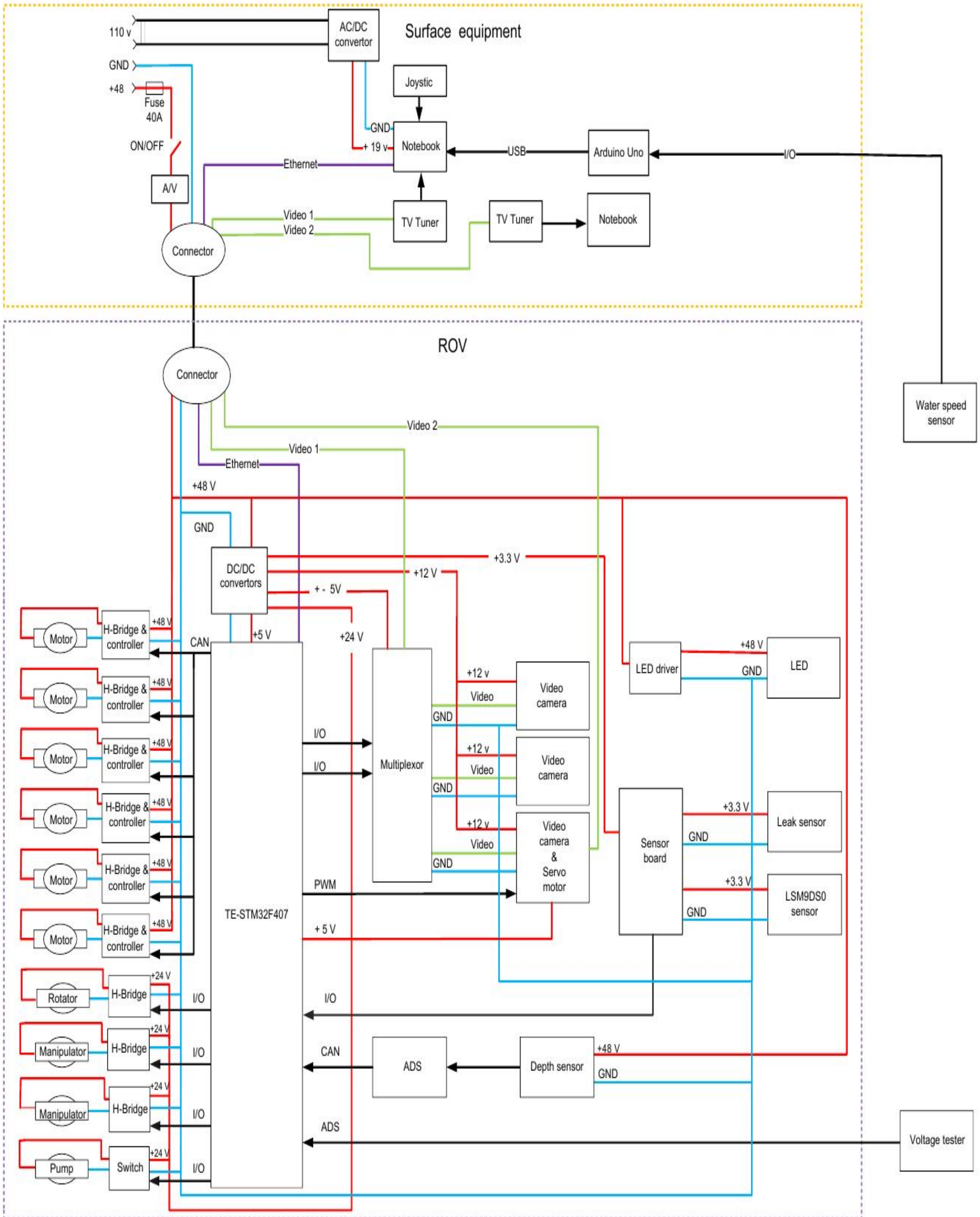


Figure 3. SID (system interconnection diagram)

Vehicle systems

Frame

Robustness of the frame is of great importance. When designing we paid much attention to safety and functionality. The frame shown in the first figure is built of combinations of aluminum, acrylic and polycarbonate sheets, as these materials are strong enough and comparatively inexpensive.

We decided to make an open frame to provide for minimum resistance and obstructions to thrust. Two flat horizontal operational zones make it possible to easily and without hindrances reach devices and electronics. A vertical flat partition between these planes secures the required structure rigidity. The Control unit is installed vertically which allowed to make the structure more space-saving. All the payload tools are placed on the lower frame for the purposes of functionality and easy access for maintenance. The upper frame houses a rotate camera to monitor the manipulator and to have a forward observation. Another camera provides for monitoring the pump and the algae collecting system. With the third camera we can see a valve turner. If compared to our previous year vehicle we managed to make this robot more maneuverable thanks to powerful thrusters.

We paid due regard to our last year's mistakes and did our best to secure a reliable communication with the vehicle. This problem was solved by joint efforts of electronics engineers and manufacturers / props constructors; we improved the connections of wires and connectors, so that these would not bend over and break down in the course of intensive operation. Every component part was designed in SolidWorks prior to manufacturing.

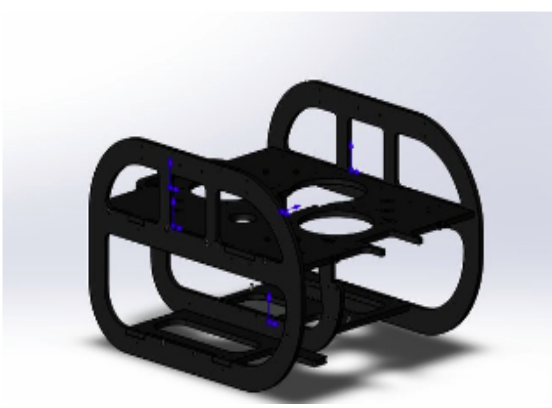


Figure 4. Frame

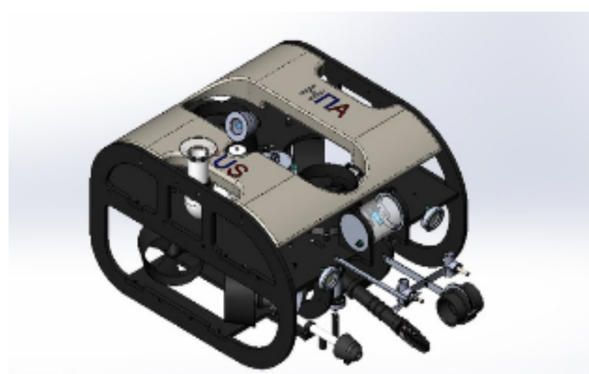


Figure 5. Complete model

Thrusters

The thruster comprises three important units:

- commutatorless motors of 48V operating voltage.

- power control unit to control their power output and the direction of rotation
- housing and thrust system to provide for waterproofness and required lift over drag ratio.

Last year we not a very successful experience in building a propulsion system, we encountered lots of difficulties in searching suitable thrusters and designing control units. The thrusters generated not enough thrust, while control units tended to fail from time to time. We debugged the system for long time, yet the outcome left much to be desired. That is why this year we decided to purchase thrusters from the Center for Robotics Development, Vladivostok. We chose powerful thrusters capable of generating a thrust of 7kg. The Power unit is made on the basis of bridge connection, on field-effect transistors which are in turn controlled by a microcontroller. A characteristic feature of these thrusters is that these are controlled by means of CAN interface.

Such a solution let us simplify the thruster connection to the central controller. To customize thruster digital control it is necessary to have them chip tuned, i.e. to assign a digital name to each of them. Thanks to the digital interface we can obtain data of the current consumed and temperature on each thruster.

Figure 6. Thruster in assembly

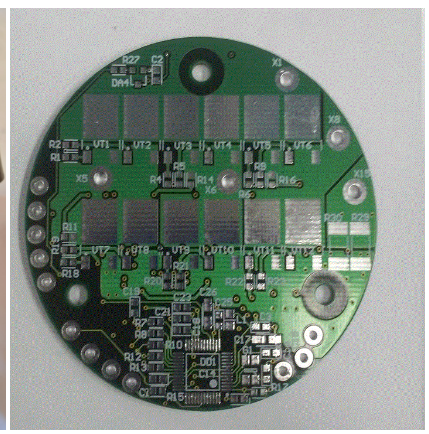


Figure 7. Thruster control unit board

Electronics unit

The principal task for the ROV electronics unit is to process the signals coming from surface and internal sensors, and also to give control signals to the thrusters and peripherals.

The unit consists of:

- TE-STM32F407 Controller board.
- Power feeding board.
- Video - multiplexor.
- Roll/pitch and acceleration sensor board.
- Leak sensor signal processing board.
- Lighting system drivers, n-bridges to control a manipulator / a pump.

Electronics unit should be of robust design and provide for absolute waterproofness, so as not to damage electronics and to prevent an electrical shock to people in the vicinity of the ROV.

The board for processing the signals coming from the depth sensor is accommodated separately. This was done to diminish the electronic interference and to obtain accurate data of the depth. The depth meter is based on the excessive pressure sensor on tenzoresistors. A signal from the sensor comes to the instrument amplifier, after which it is digitized by a 16-bit analog-digital converter. Thence it is transmitted through the CAN interface to the main controller. Also, for more accuracy in measuring a thermal resistor is built in the system. Thanks to that we can learn the temperature of the ambient water and introduce the factors affecting the final outcome. This is of particular relevance when operating in suggested Arctic conditions.

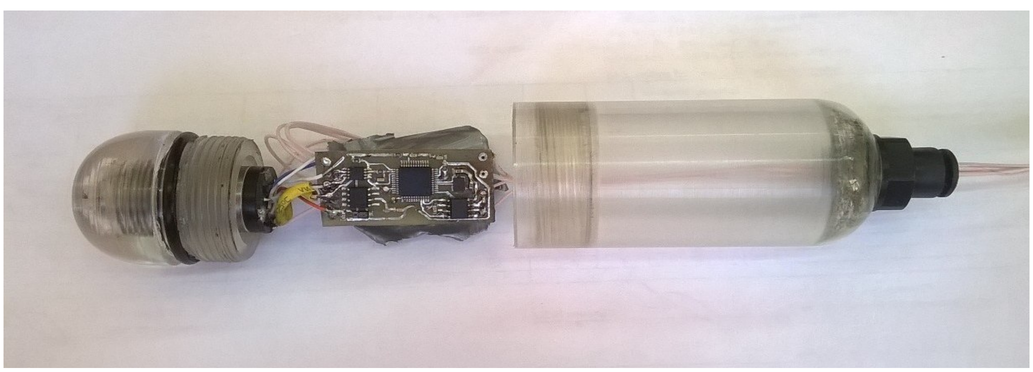


Figure 8. Pressure sensor with connected to it converter interface CAN

Power feeding board

To provide for on-board electronics power supply we developed a special power board. It is necessary for converting high input voltage into lower voltages consumed by our ROV electronics and performs functions of regulation and protection from inconsiderable interferences. Input voltage of +48V is converted into lower ones using several DC/DC converters. Converter inputs and outputs are additionally filtered from cross coupling and EMC noise. DC/DC outputs secure stable voltages of + 12V, +5V , +5V , +3.3V, +24V. These voltages are needed to feed autopilot, video cameras, pump, and manipulator's electronics. To enhance the device reliability we selected the breadth of the plains to be equal to 1.5 – 2mm. also for the same reason the distance between the plains was selected to be from 1mm to 2.5mm, which provided for electric reliability.

On-board control system

To have the problems of controlling the robot and measuring an object parameters solved we made a decision to make two interfaces for interaction with the robot.

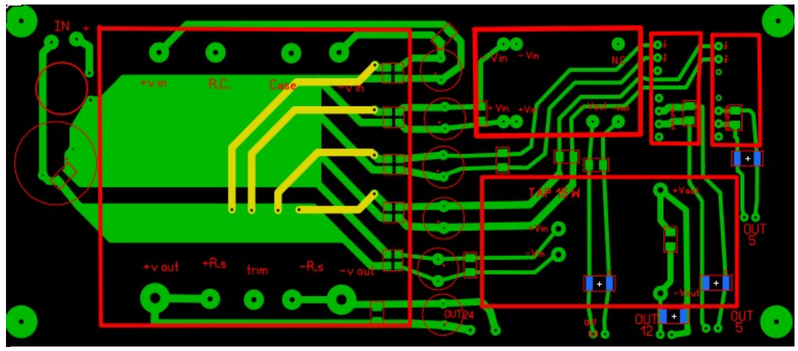


Figure 9. Power supply board (CAD model)

The first interface was created to control the robot directly.
It is its duty to transmit video images from all the cameras to the surface and also to maintain communication with the controlling mechanisms as well monitoring data received from sensors. Besides, it is possible with the help of this interface to do the vehicle stabilization factor calibrating, each thruster go-no-go testing. In its turn, the interface was also provided with a capability of monitoring each separate robot component's problems. In case of failure, or lack of communication with it an error message is output. Should communication be lost completely an audio alarm is sounded. Furthermore, joystick sensitivity adjustment ability is available. If selecting a full sensitivity the joystick operates at the upper limit of sensitivity, while in lite mode it uses only 75%.

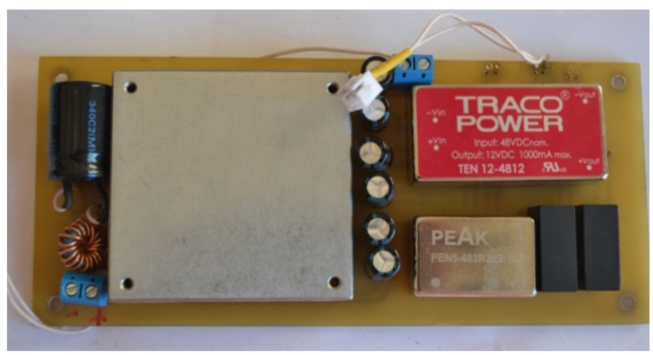


Figure 10. Power supply board (real thing)

At the same time the second interface is used for measuring the parameters of the objects under study. This interface's operating principle is very simple: making screenshots from the video output and thence measuring parameters of the object using the method of finding the desired size to match the known one. The second pilot takes pics from the cameras monitoring the object being measured, sets the initial and final points of the known and desired objects, determines the size of the known object, afterwards an automated calculation of the desired object's size is done.

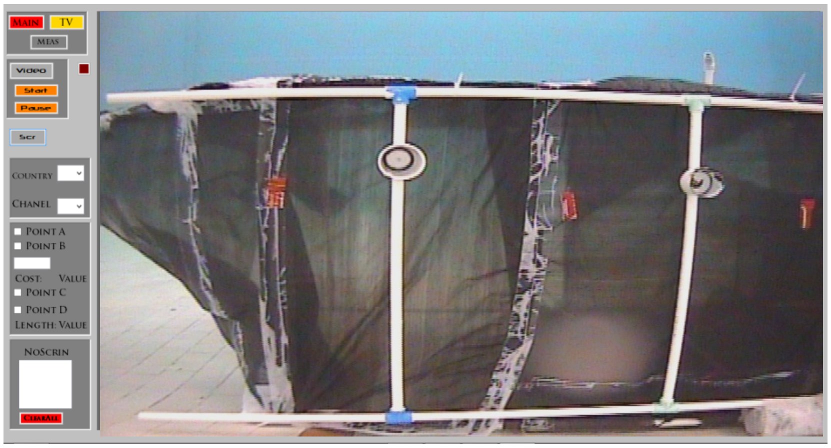


Figure 11. Interface of image processing

Cameras

Cameras are basic senses with the help of which a pilot controls the vehicle. That is cameras should secure monitoring sufficient for effective control. Having tried several combinations (beward mx100, microdigital mdc-10f, ace-m321pup4) and reconfigurations we arrived at the decision to select 3 cameras(Sony effio, function: one rotate and two fixed).

When selecting the camera type we were guided by the following criteria: optical sensitivity, viewing angle, size. We selected one naked color camera 1/3’ П3С (CCD Sony effio (700 TVL, 0.001Lx, 72degrees). We designed the cases for the cameras in SolidWorks, and then according to the drawings we ground these on a lathe machine from an acrylic rod.

Figure 12. Video camera in a sealed housing

Thrusters

Our ROV’s tether is structurally composed of:

- Power copper cable with a cross-section of 4mm2, to supply power feeding to the ROV
- Ethernet cable serving for sending controlling signals to a microcontroller, and also for a feedback with our ROV.
- Coaxial cable serving for sending video to the surface.

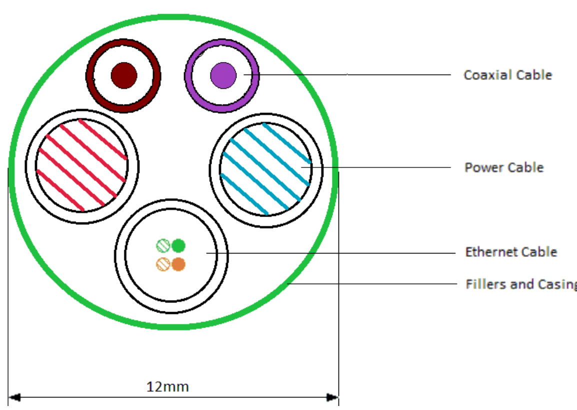


Figure 13. Tether
(schematic sectional view)

To protect from water ingress we used a hose of 12mm in diameter.

Surface equipment

Control board

The control board is the link connecting operators and ROV. The control board performs functions of commutation, power supply on board, and it also accommodates equipment to control the vehicle and to provide for a feedback with it.

The control board of our last year version performed all the functions mentioned above. However it lacked the key thing – the versatility. In order to pilot the ROV we had to take not only the vehicle itself, a joystick, and a control board, but also a laptop. In this connection an idea came to our heads – to accommodate a laptop and a control panel in a single housing, placing a display in the control board case's cover, while the keyboard and the under-the-hood – in a lower carrying part of the case. By doing so we made the control board more functional and versatile.

Figure 14. Control board (with a display removed)

Considering its functions the control board consists of the following parts:

1) Power unit with the output voltage of 48V, for testing purposes and for exercises with the ROV.
2) Various slots/plugs and couplers:
   - 2РМДТ27КПН - tether from the ROV is connected to it. It serves for supplying power on board, sending controlling signals to the vehicle, for a feedback with the vehicle, as well as for sending video signals.
   - 2РМД24Б10Ш5В1 is a slot through which the 48V current is supplied to the vehicle in the course of the MATE ROV 2015 competitions.
   - 2 supply line plugs for 110-220V. One is intended to supply voltage to the laptop power unit. The second one – for feeding AC/DC converter, from which the vehicle is supplied with power when not engaged in competitions.
3) A 15" display, located in the control board case's cover
4) A lower part of the laptop with the keyboard, touch-pad and the laptop's under-the-hood

5) A digital avometer, necessary for displaying the voltage and the strength of the current consumed from the power supply source

6) A laptop’s power unit.

Payload tools

Lights

Our vehicle is supposed to operate in underice conditions, where there is insufficient light intensity. To provide for standard visibility a decision was made to install light sources on the vehicle. For the purpose we took two light emitting diodes Cree CXA2011, with power feed voltage of 48V these are capable of, они способны radiating a light of 900 lumens. In 2014 in the course of the MATE ROV Competition the diodes of the kind proved to be good, but they require sufficient cooling, and that’s why we made the case of aluminum.

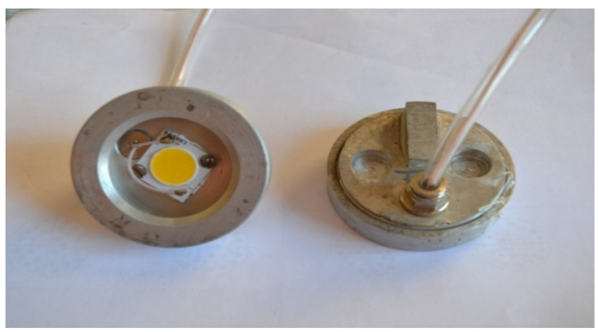


Figure 15. Lights

Valve turner

As according to the task our ROV is to turn in / out valves in pools Nos. 2 and 3, and this is rather inconvenient to be done by means of the manipulator, we invented a tool to facilitate the process. It looks like an upturned letter “y”. In the bottom of the vehicle a small motor of frequency of approximately 3.25 rotations per 9 seconds is installed, and the tool of ours is secured to the motor’s shaft.

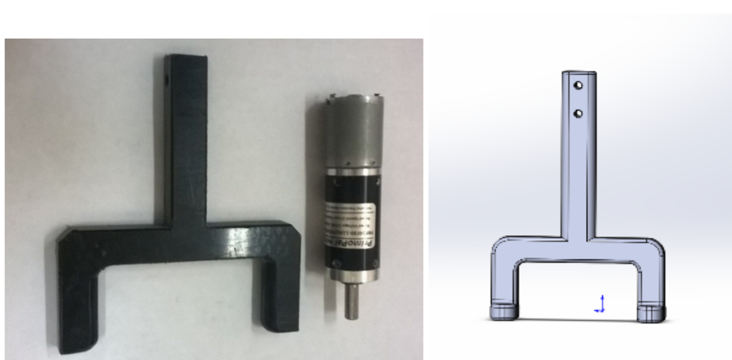


Figure 16. Valve turner (CAD model and real thing)

Tube grabbe

We thought over how to accomplish the task for the second pool where we're to take a part of corroded section and pick it up to the surface, and eventually we decided not to invent anything. We bought a special tube clip, made two small scores to ease snapping and secured it to the vehicle. Having leaned upon the tube with the clip, the vehicle with the help of its motors and its own weight generates a necessary pressure on the tube and clip snaps embracing the tube. Then one can pick the tube up to the surface.

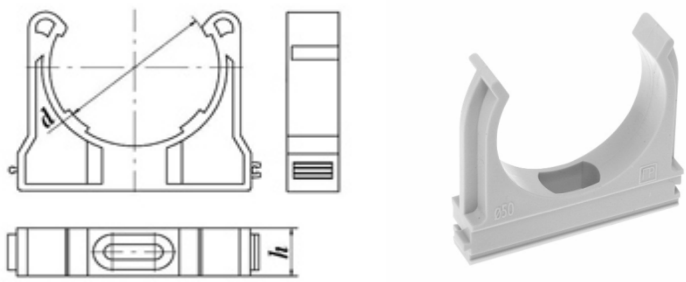


Figure 17. Tube grabbe (CAD model and real thing)

Manipulator

To solve specific problems such as: installing an acoustic sensor, collecting sea urchins, securing Liftline, and other tasks involving grabbing some objects, we decided to use a manipulator of ROVBUILDER make with two degrees of freedom, as it had demonstrated excellent performance in the previous competitions. For this manipulator we developed a control unit, based on decoder 74HC139 and optical relay PVG612, and such a choice is predetermined by its simplicity and consequently reliability.

Figure 18. Manipulator

A manipulator's operating voltage is 24V. the manipulator's squeeze strength is 7.5kgf. The maximum grabbers' opening range is 75mm. the grabber's shape is a classic one, representing a claw which allows for grabbing objects of practically any shape.

A system for the collection of algae (ball ping-pong)

Figure 19. The pump

We built the algae (table-tennis balls) collecting system on the basis of the pump capable of producing the pressure sufficient to retain an object under water and in open air. We tried a lot of versions with different shapes and the diameter of the hopper to collect the samples. The best performance was shown by the hopper with the diameter lesser than that of the ball. Such solution provides for firm adherence of the ball to the hopper.

We approach the ball and suck it with the hopper. Keeping pumps working we deliver the ball to the surface. Such method of collecting samples was selected due to its simplicity and efficiency.

Voltage measurement unit

In the course of discussing the tools needed to accomplish the mission tasks our team came to an understanding that it would be more logical to make a device, that would lie on the oil platform anodized leg prop accounting its peculiarities (round shape and bellying bolts). As a result a decision was made to manufacture a casing of the tool of a half of a PVC tube, while terminal pads of an ordinary Brillo pad. Such a solution is caused by a possibility to have an oil platform leg tightly "hugged" by a tube half, while rather elastic current-conducting sponge secures a reliable contact with the required bolt. The data obtained from this tool to be processed by the tool's brains - STM32F407

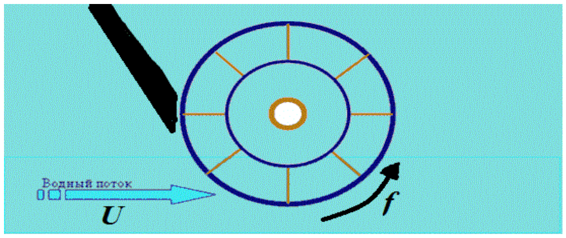
Water flow rate measuring tool

To have a water flow rate measured it was decided to manufacture a separate tool, representing a propeller, the rotation frequency of which is in proportion to the sought water flow rate.

When working on the tool we had to find solution to the following problems:

- The tool to be calibrated (learn k), but for the purpose it is necessary to create a flow with the rate known
- half of the propeller to be closed, as it wouldn't rotate otherwise
- complexity of manufacturing the propeller itself. The optimum parameters to be selected, which requires making a number of props

- the wheel mounting not to offer resistance for the tool to have a greater sensitivity
- the tool to be mounted in a certain way with regard to the flow



$$U=k*f$$

Figure 20. Schematic representation of the operating principle of the water flow rate measuring tool

Troubleshooting Techniques

While we were engaged in creating the vehicle we encountered quite a lot of technical challenges. The major challenge was Autopilot leakage.

In the process of a part (an autopilot cover) manufacturing a grave mistake was made – its outer radius was lesser than required, resulting in fittings not tightly adjoining the cover, and consequently in not securing the proper waterproofness.

This challenge was addressed in the following way: the cover edges were ground with a file and afterwards all the fittings sat in their proper position.

The problems with ensuring the tool to be waterproof didn't stop with that. One of the orifices intended to maintain the Autopilot cover in its place was made abusing manufacturing standards, and this problem was quickly and efficiently solved through welding the incorrectly made orifice. However the welding happened to be nondurable and leaked water. With the second attempt through re-welding the cover we eventually got rid of the problem.But even then our problems with waterproofness persisted! The purchased thrusters turned out to be nontight and leaked water and owing to that through the connecting tubes water entered the electronics unit. The solution to the problem was found through re-assembling the thruster casings and applying sealing matter to all the joints.

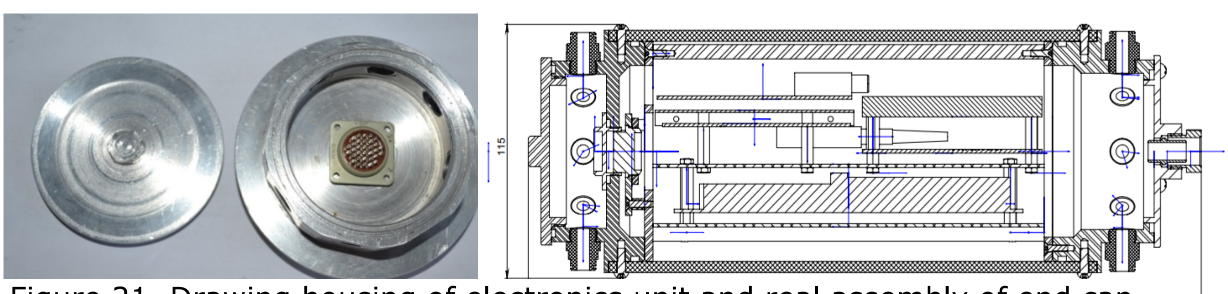


Figure 21. Drawing housing of electronics unit and real assembly of end cap

Safety

We divided all the safety rules into three groups:

1. Rules for safe vehicle building;
2. Protection;
3. Rules for the ROV safe operation.

To ensure safety when building the vehicle we had regular professional briefings on the occupational safety. As a result our vehicle acquired some specific safety features:

- warning stickers on thrusters;
- fuses;
- LED alert alarms inside the vehicle under the casing; (not exact)
- Leak sensors of our own manufacture.

To ensure safe operation of the vehicle we worked out rules for ourselves and produced an operating manual, including pre-start check, monitoring during operation and after-finish check.

Pre-start check	√
① Check fuse	
② Check AV-meter	
③ Check all connections	
④ Check commutation with ROV	
⑤ Check leak sensors	
⑥ Check depth (pressure) sensor	
⑦ Check cameras	
⑧ Check thrusters	
⑨ Check manipulator	
Monitoring during operation	
① Monitoring AV-meter	
② Monitoring commutation with ROV	
③ Monitoring leak sensors	
④ Monitoring trim sensor and depth sensor	
⑤ Monitoring thrusters health	
Check during operation	
① Check mechanical damage	
② Check all connections	
③ Check water leakage	
④ Check the integrity of the thrusters	

Challenges

Technical

The process of manufacturing an ROV is quite complicated, and we constantly encountered some problems in the course of our work.
Pulling the tether was one of the challenges! We were eager to make it aesthetically pleasing and generally robust, so we purchased a hose with a minimum allowance for our cables, which was actually the cause of our troubles – we were trying in the run of three days to pass the tether through this hose, and something kept on going wrong: be it a strong wind that prevented us from doing so on a building's roof, or an unreliable fish line parted, when half work had been done. Eventually on day three the work was completed! But we soon learnt that it was done IN VAIN.
While pulling the cables through the hose optical cables were damaged, and we then decided to give up on using them this year (they are too fragile, and furthermore we had no time to try different configurations with optical cables), so we purchased necessary cables and another hose, passed everything anew again and that was the end of our problems with the tether.
When finding solutions to such problems we came to realization that it paid to make more effort to overcome any problem!

Non-technical

In winter our team captain had his shipboard training on board the training vessel "Professor Khlyustin" for 3 months, so actually within that period of time we worked without proper work management. And it is winter time when all the design works take place, when component parts are purchased for further transportation to the Far East of Russia which takes so long time. Most of the team members didn't have any experience of practical work; it was very difficult for them to make decisions on further project development. In the meantime the team captain got in touch quite seldom, only when his ship called at some ports. He did send some groundwork and diagrams, but these were not enough. A big project implies personal interaction, ongoing meetings and discussions of all the problems, because in the vehicle everything is interlaced into a single whole, which requires coordinated work of electronics engineers, software engineers, and manufacturers / props constructors. Despite all the difficulties we managed to complete the vehicle's designing process and set up to its assembly.
We also couldn't escape problems so typical for foreign teams who needed to be issued visas to Canada within a short period of time. That requires gathering a big package of documents and correctly fill them in. regretfully, the final decision on the composition of our delegation to go to the competition was made at the last moment, so there was

very little time for processing all the documents, but we succeeded to do it before the deadline.

Lessons Learned

Technical

1) We became aware that when doing any work the following is of essential significance:

- at the stage of designing it is the sequence of steps and development of required documentation (sketches, diagrams, drawings, calculations).
- at the vehicle testing stage it is methods and programs.
- at the stage of work on the project it is clear-cut segregation of duties, planning.

All of these help avoid plenty of mistakes, misunderstanding, and regarding design engineers these allow to significantly reduce the time the time of development.

2) we learnt how to use CAD instruments such as SolidWorks, AutoCAD, and Altium, etc.

3) we learnt how to independently design printed circuit board from scratch, and how to transfer to textolite with the use of the toner transfer method

The method is as such: using only a laser printer, glossy paper, $FeCl_3$, we were able to produce practically all the printed circuit boards for the ROV of ours (power board, LED driver, roll/pitch sensor, manipulator control board, pressure sensor, etc.).

Lessons Learned Interpersonal

Teamwork is the cornerstone of success in any job of work, including designing and building an underwater vehicle. The reason is that when you work alone there is a fat chance to miss some obvious gaps and errors in your work. Against such a background conflicts arise, when a person does not respond to criticism positively, is not used to remarks, and hasn't worked in a team before. Or, as another example, when an opinion of one person is partially or completely different from that of the team's common opinion, then conflicts may arise between an individual and a group, and it is mentors' job to defuse or resolve a conflict.

Teamwork is motivating for achieving a result, but working in a team is not easy.

And we failed to comprehend this at the beginning. The work was extremely uncoordinated and the progress was slow. However step by step we started to work cooperatively, considering everyone's opinion, and eventually we turned into a tight-knit and strong team.

Future Improvement

Future improvements into the vehicle design are aimed at making it more robust and more ergonomic. With every coming year the team cranks it up a notch in its knowledge and this allows for using more sophisticated technical solutions. We're planning to implement the data exchange between the vehicle and the control board using optical fiber. Optical systems ensure high definition of the video and reliable communication, without any losses, but these require attitude of care towards them and experience in working with optical communication channels. This year we have already carried out a number of experiments, but decided that we aren't ready to work with such "fragile" equipment. We will also work on the vehicle's styling design, paying attention not only to the functional properties, but also to good looks and general concept, because an appealing vehicle is easier to be sold to a potential customer. In the majority of the companies involved in manufacturing sophisticated technical devices, they pay a great deal of attention to a good styling design and we intend to look up to the tops in their field.

Reflections

Alena Sarycheva

Before being involved in this project I had no experience in teamwork, while my skills in electronic devices weren't that good. So, my participation in the ROV design and building was a great stimulus for enhancing my knowledge in electronics. I learnt many new things about circuits engineering and got acquainted with the basics of designing electronic devices from scratch. Moreover I got invaluable experience in making printed circuit boards, which was a completely new thing for me.

Anton Kasatkin

The work on the ROV was the most interesting event in my life this year. When I joined the team I had no practical experience in circuit board design, in soldering, nor I had any idea of circuit engineering, so the work was hard for me, but with every new difficulty an interest to our joint work grew stronger and stronger which kept on motivating to do better and better. We managed to resolve all the conflicts arising in the process of work between the team members very promptly, because it is the team work that allowed us to successfully complete the project.

Alexandr Morozov

This is first time I participate in an ambitious project. It is thanks to this project that I learnt many new things, learnt how to apply my knowledge in practical activities. Working in a team I understood that an ambitious project demands a serious attitude to everything:

careful designing of individual units and components using sophisticated software, such as SolidWorks, AutoCAD, a thorough study of and corrective actions to individual components, elaborating and finding solutions to complicated engineering problems. It was new and interesting for me to work in a team of peers interested in a common goal – building a robot.

Nikolai Iatcenko

I am with this project for the second time. I want to stress that thanks to my involvement in the project I have got vast experience in many areas: have got deeper knowledge in electronics, circuit engineering and electronic device design starting from scratch. A novelty for me this year has been an experience in mechanical design. In order to achieve the goal set, namely to design and build an ROV control board I have studied the theory and learnt to work in special programs - SOLIDWORKS and ALTIUM DESIGNER.

And the main and most valuable experience I've got through my involvement in the project is that of working in the team of like-minded fellows, united in aspiration to make the best ROV.

Nikolai Golub

When working on this project I learnt how to work in SolidWorks 2013 program. Also I've got a lot of knowledge in underwater robot design and materials used in their building. The teamwork has been focused on achieving common goals, and the responsibility has been shared by all the team members. Through coordinated efforts we have been able to accomplish any given tasks, which are otherwise too hard and labor-consuming for a single person.

Oleg Kozhevnikov

Another reason not to be bored to death, another year to be a lucky ROV engineer, another great press of work and a common purpose – not to lose.

During two years of my being with the project I have been like a machine tool turned on continuously. Because you have to meet a range of various challenges, and the longer you work with the mentors, the deeper you are inspired with what is known as Technical Merit, engineering school traditions, and some tasks that used to seem hard and spanless before are now quite solvable.

In the capacity of the team captain I have learnt to control the whole process of the vehicle's creation and preparations to competitions. I have had to make decisions not only pertaining to electronics where I'm specializing, but in the other areas pertaining to the project as a whole.

This year I have worked with new high-precision equipment, conducted optical fiber system tests, though these were not incorporated into the vehicle's final version, and besides it was the first time I used CAN interface.

The skills in using cutting-edge technologies and operating modern equipment, as well as in leading a team are invaluable for me.

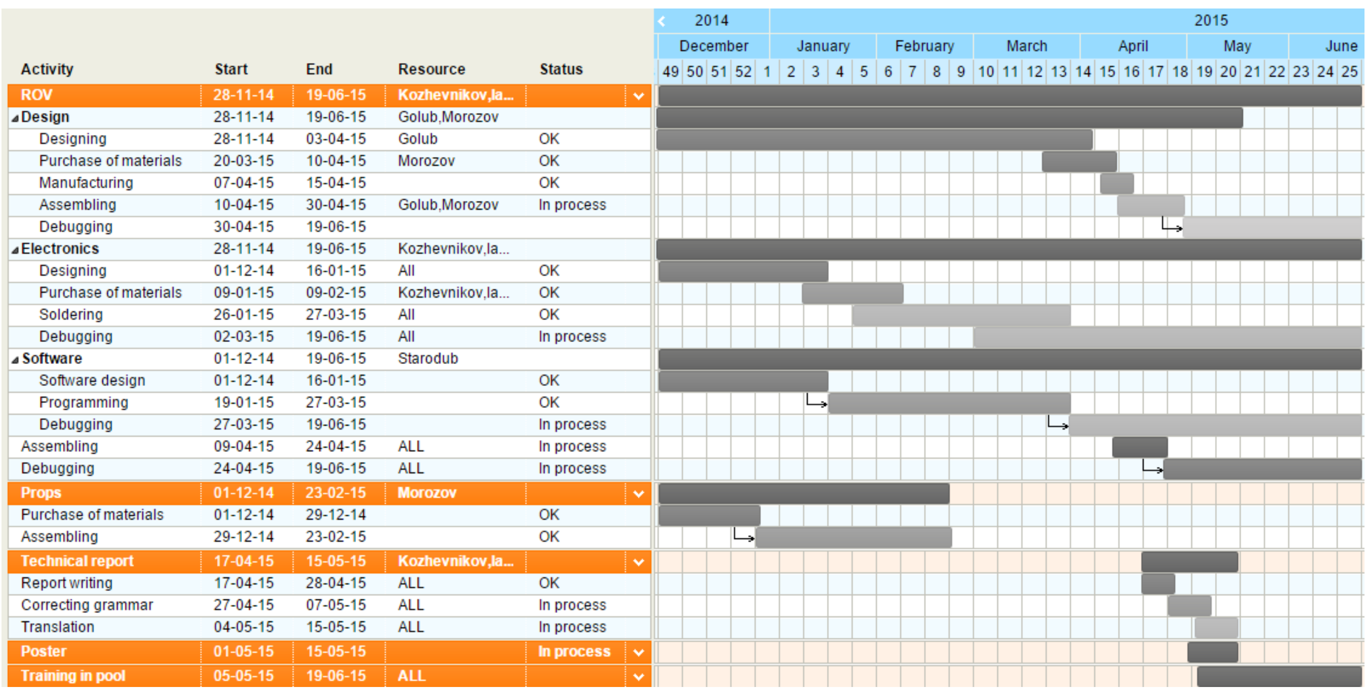
Dmitrii Khavshakov

As for me my participation in this project was unexpectedly hard. Knowledge of theory with no practical skills at all turned to be useless. Absence of teamwork skills, failure to apportion my time, to plan, to set the timeframe for the tasks greatly hindered the process of accomplishing the tasks apportioned to me. It was availability of the team and the mentors who I could always seek advice from that contributed into acquiring the said skills.

Ruslan Starodub

While developing interfaces for the robot control I plunged even deeper into learning software programming languages. I have acquired a vast experience in programming technical aids of control and monitoring. I mastered new libraries such as DirectX SDK. And of course I got unforgettable skills in teamwork.

Teamwork



Activity	Start	End	Resource	Status
ROV	28-11-14	19-06-15	Kozhevnikov,la...	
Design	28-11-14	19-06-15	Golub,Morozov	
Designing	28-11-14	03-04-15	Golub	OK
Purchase of materials	20-03-15	10-04-15	Morozov	OK
Manufacturing	07-04-15	15-04-15		OK
Assembling	10-04-15	30-04-15	Golub,Morozov	In process
Debugging	30-04-15	19-06-15		
Electronics	28-11-14	19-06-15	Kozhevnikov,la...	
Designing	01-12-14	16-01-15	All	OK
Purchase of materials	09-01-15	09-02-15	Kozhevnikov,la...	OK
Soldering	26-01-15	27-03-15	All	OK
Debugging	02-03-15	19-06-15	All	In process
Software	01-12-14	19-06-15	Starodub	
Software design	01-12-14	16-01-15		OK
Programming	19-01-15	27-03-15		OK
Debugging	27-03-15	19-06-15		In process
Assembling	09-04-15	24-04-15	ALL	In process
Debugging	24-04-15	19-06-15	ALL	In process
Props	01-12-14	23-02-15	Morozov	
Purchase of materials	01-12-14	29-12-14		OK
Assembling	29-12-14	23-02-15		OK
Technical report	17-04-15	15-05-15	Kozhevnikov,la...	
Report writing	17-04-15	28-04-15	ALL	OK
Correcting grammar	27-04-15	07-05-15	ALL	In process
Translation	04-05-15	15-05-15	ALL	In process
Poster	01-05-15	15-05-15		In process
Training in pool	05-05-15	19-06-15	ALL	

Figure 22. Gantt Chart

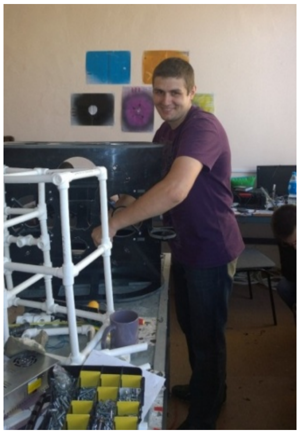


Figure 23. Golubev are collecting device

It is our opinion that virtually any aim is attainable provided there is a good team and elaborated plan, so we started our work with drawing Gantt chart and clear-cut allocation of duties. We could rely on our team members only as our mentors have commitments outside the university and are therefore very busy. We divided into three groups: manufacturers / props constructors, electronics engineers, and software engineers. Each group was headed by a chief to coordinate the group's work. Also we had a division of team roles. CEO was in charge of the project as a whole and for interaction with the mentors, CFO was responsible for the project financing and purchases, CTO was in charge of manufacturing, while CAO – for relations with the University administration.

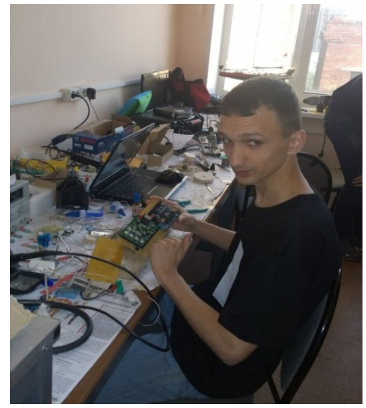


Figure 24. Oleg are soldering boards

To keep the team members aware of the project progress, we had regular meetings every week to discuss challenges met within the past span of time. That gave an opportunity to think of something conceptually new thanks to sharing views from other team members. Besides, these meeting were the place to place any given task on the priority list and to monitor the progress of all the work done by that time.

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ЦЕНТР РАЗВИТИЯ РОБОТОТЕХНИКИ