Admiral Nevelskoy Maritime State University

Maritime State University Robotics Team

Members

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Dmitritry Nechepurenko – Programmer
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Наставники

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Оглавление

Abstract

Maritime State University Robotics team is taking part in MATE ROV competitions for the third time. We developed totally new robot "Space wolf". This ROV create specially for the following tasks: mission to Europa, mission-critical equipment recovery, forensic fingerprinting, etc.

"Space Wolf" is result of carefully planned hard work which has been conducted since November 2015.The vehicle tested differently with purpose to check its reliability. The ROV's budget is 2500 USD.

Construction of the vehicle consist of polypropylene frame, aluminum cylindrical electronics unit, manipulator and handmade thrusters. Its size is 506x384x412 mm. Software was written in a programming language C++ in IDE QT, that provides cross-platform software.

This technical documentation contains description of vehicle's design and review of internal systems, payload and software. Also it include some words about our team and the difficulties which appeared during the development.

Figure 1 - Left to right: Vladislav Kutsenko, Vadim Sorin, Petr Gorelov, Aleksandr Morozov, Dmitrii Nechepurenko

Figure 2 - ROV "Space Wolf" with surface equipment

Project management

All stages creating of ROV are long, sometimes very hard, work. We need to do everything promptly and smoothly understand teamwork for successful implementation of this goal. It is very important that each of the team members are not "burned out" and carried their initial ardor and interest in the project through all process, from start to finish. Project planning and maintenance of moral spirit of the team are the key to success! In the beginning we arranged meet once a week by students and a fortnightly common meet with mentors for solving problems and questions. Also plan of works was created and each team member must perform work in accordance with it. All team members have a mentor and have to meet with him and do their work under his leadership. Despite the strict rules are not always able to keep within the time because of unexpected case. But clear organization, teamwork and experience of mentors helped us to cope. We have achieved the desired result through this approach!

Budget

Electronic(underwater part)			
Item	Amount	Value, USD	Reused
Small parts (capacitors, diodes, optrones)	-	27.58	
TE-STM32F407	2	151.53	
STM32F373CCT6 ST	2	10.96	
REF196GSZ-REEL7	2	7.75	
PVG612APBF IR	10	57.64	
MPXM2202GS FRS	2	10.34	
LM5007MM/NOPB	2	5.59	
AD8184ARZ	2	8.61	
AD8009ARZ	2	6.88	
USB-to-COM	2	18.08	
Thrusters.	6	7 354.46	Reused
Manipulator	1	766.09	Reused
Cameras.	3	248.21	Reused
Pressure sensor.	1	27.58	Reused
DC-DC conventors	-	358.53	Reused
Total:		9059.83	
Electronic(surface part)			
Laptop	1	536.26	Reused
TV-tuner	1	22.98	Reused
Monitor	1	84.27	Reused
Pelican case		145.56	Reused
Joystick	1	38.3	
Total:		827.39	

Mechanics and materials			
Fittings	-	183.86	Reused
Cap PP20	1	1	
sealing rings	-	10.3	
Screws and nuts	-	16.96	
Pipe for fittings	-	15.63	
Tap	-	6.59	
Textolite 2mm	-	8.69	
Silicone hose 26m	-	111.54	
Power cables 52m	-	20.72	
Coaxial cable 26m	-	19.92	
Ethernet cable 26м	-	19.92	
Materials for the manufacture of models	-	255.87	
Total:		671	
Service			
Polypropylene cutting	-	197.65	-
Aluminium cutting (sealed connector)	-	38.3	-

Total: 703463,14 USD

Mentors	**Hours**
Sergey Mun	**220**
Denis Mikhailov	**200**
Nikolai Sergeenko	**230**
Igor Pushkarev	**180**
Andrey Kushnerik	**220**
Total:	**1050**

Students	Hours
Vadim Sorin	**450**
Dmitrii Nechepurenko	**420**
Aleksandr Morozov	**450**
Petr Gorelov	**420**
Vladislav Kucenko	**450**
Total:	**2100**

Cost analysis

In the design process has been audited and compiled a list of necessary materials. Since these competitions are set strict weight and size limits, our team picked up the materials with criterias such as lightness, durability, low cost. We used the following materials: aluminum, acrylic, polypropylene, izopink. These materials have the following advantages: aluminium - light weight , cheap cost, durability, high heat transfer coefficient, modern aesthetic appearance; izopink - waterproof, high compressive strength and moisture, high strength at the expense of a homogeneous structure; acrylic - ease, transparency, sufficient strength for our purposes of its use; polypropylene - resistance to temperature changes, aggressive substances, wear, frost; the ability to keep the shape; high strength, the sheet is flexible in a cold state; ease of handling; environmentally friendly material; light weight; minimum electrical conductivity; resistance to mechanical damage.

Reporting

ROV's creation is a big project both technically and economically. We had to plan our future costs and convinced the university administration and the sponsors on spending money. It started with team meeting where we decided what old parts, materials, elements, we can use in this year. Decision was taken after a lot of tests! Fortunately the most expensive parts : thrusters, manipulator and cameras could be reused in our project. Of course it wasn't all and we started designing the machine, at the same time watching a lot of Internet shops and all the shops of the city in the search for high-quality and cheap things. As a result, each member of the team prepared a list of the necessary things and after the next meeting the final list was made and presented to the university and sponsors. This list was approved and creation "Space Wolf" began!

Design rationale

To simplify design process, we used multistage approach to reduce quantity of mistakes and revisions during development of design.

Everything has begun with brainstorming in the course of which many creative ideas and offers on a board or on a sheet of paper, as shown in figure 4 have been stated. All options were carefully thought over by such criteria as: cost, complexity of production, operational reliability. The team has together chosen the best ideas for further realization.

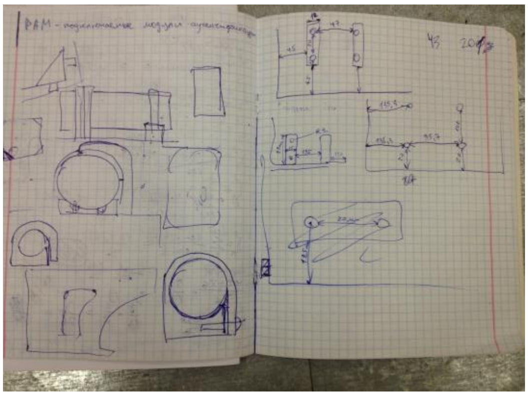

Figure 3 - Sketches

After performance of missions we have defined the list of necessary components of the device:

- **Frame –** all elements of the device will settle down on it. It is the ROV key element. Frame consists of vertical and horizontal components. The majority of the equipment is consolidated on horizontal. Vertical carry out the supporting function.
- **Buoyancy –** material less dense than water. At the expense of her ROV will stay afloat.
- **The autopilot –** in him will settle down all onboard electronics. In order that all electronics weren't affected by water the block of electronics shall be hermetic.
- **Thruster system** – consisting of electric motors and screws. The vehicle has 1 vertical and 3 horizontal thruster. It is enough for normal piloting of the device.
- **Attached equipment:**
  - *video cameras (for a review of the situation around ROV)*
  - *manipulator (to be able to take / pull / flip anything under the water)*
  - *pressure sensor (to determine the depth, as well as to implement stabilization)*
  - *hook (to hook the handle and open the door)*

Then, the final versions have been implemented in digital form in SolidWorks. The files were prepared for mechanical processing, converted to the desired format (DWG) to be sent to the company for the manufacture of parts that we need. Some parts on the machine have been made on a 3D printer in the "Robotics Development Center." Also, small and simple parts were made by hand.

Figure 4 - Render "Space Wolf"

The vehicle was designed from the ground up for mission-specific upcoming competition. Some components - updated previous projects team competitions, such as our new mounts rotary camera and mounts manipulator. All components of the vehicle will be described in the sections below.

Each member of the team during the development of new parts for the vehicle, must decide whether to make or buy the item yourself. Components that can be made at home, usually more economical to manufacture. Components that require specialized manufacturing processes, which exceed the possibilities of the team (such as welding or large-scale printing), are given to the production of a commercial company.

Safety

We separated safety rules in three groups:

1. Rules of safe construction of the ROV;
2. Protection;
3. Rules of safe maintenance of ROV.

For safety reasons when assembling the device, we held regular professional briefings on Safety Instructions.

As a result, our ROV has gained their own specific security features of:
- Warning labels on the thrusters;
- Fuses ;
- Leak sensors.

For safety reasons of the apparatus we have made for themselves some rules and operating instructions which contain pre-starting checks and monitoring during operation of and check after the completion of the work.

Pre-start check	**√**
Check fuse	
Check all connectors and cables	
Check mounts	
Check current and voltage	
Check leak sensors	
Check data from the ROV sensors	
Check cameras	
Check thrusters and manipulator	
Monitoring during operation	
Monitoring leak sensor	
Monitoring data from the ROV sensors	
Monitoring Current and Voltage	
After-finish check	**√**
Check mechanical damage	
Check all connectors and cables	
Check the structural integrity of thrusters and propellers	

Figure 5 - Check list

Philosophy

Security is the foundation of the team's success! Each of us, every day doing the work, which is at the uncorrect approach to it, can lead to disastrous consequences. However, the constant discipline in the team, order in the workshop, record keeping and fulfillment of strict safety rules, like you can not give a understanding of what we are doing serious business.

ROV safety

Check before starting:

1. Checking the fuse.
2. Checking voltage.
3. Checking all connections.
4. Checking switching from remote control.
5. Checking leak sensors.
6. Checking the depth sensor.
7. Checking the internal pressure sensor.
8. Checking of cameras.
9. Checking thrusters.
10. Checking the manipulator.

Monitoring during operation:

1. Monitoring of voltage and current consumption.
2. Monitoring of the commutation with ROV.
3. Monitoring of leak sensors.
4. Monitoring and depth sensor.
5. Monitoring of the internal pressure sensor.
6. Monitoring of thrusters.

Check after the completion of the work:

1. Checking mechanical damage.
2. Checking all connections.
3. Checking leak sensors.
4. Checking thrusters work.

Machine systems

Frame

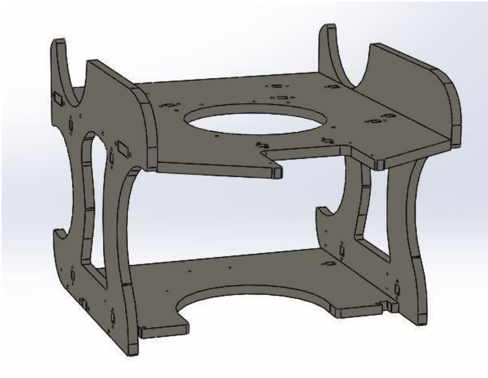

Figure 6 - Frame

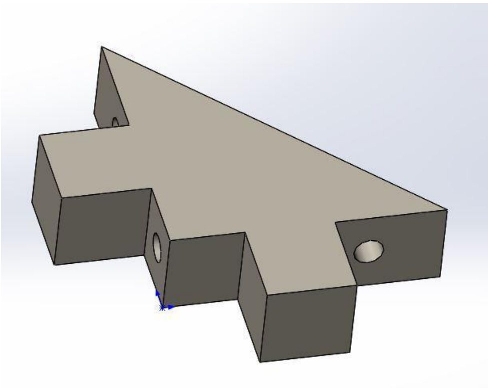

Figure 7 - Corners of the frame for rigidity

Great importance is the reliability of the frame. In design we focused particular attention to security, and functionality. The frame shown in Figure 6, is constructed entirely of polypropylene because this material is strong enough, light and relatively inexpensive.

It was decided to make an open frame to provide a minimum of resistance and obstacles to the pull. Two horizontal flat working area allow easy and without hindrance access to the devices and thrusters. Triangular corner between the two planes, which are represented in Figure 7, provide the required rigidity of the structure. In the side walls of the frame are made cutouts for good access to the electronics unit as well as for less water flow resistance. All tools are located at the bottom of the frame in order to function and easy access for maintenance. On the top frame installed connector to the cable and turning camera, which allows controlling the position of the object in the manipulator and provides a frontal view. Another camera provides the observation the manipulator. With the help of a third camera we see the hook to open the door. Compared to last year we were able to make the machine more maneuverable robot, light and compact.

Thruster system

Figure 8 - Thruster

This year we decided to use last year's production of thrusters "Center for robotic development" from Vladivostok, because they are well proven themselves in previous competitions. We chose the powerful thrusters that are able to generate thrust in 7 kg. The power part is realized in a bridge circuit, the field effect transistor which in their turn controls the microcontroller. A distinctive feature of these thrusters is that their management is done via the CAN interface. This solution allows us to simplify the connection thrusters to the central controller. To configure a digital thrusters control they need to be programmed, that is, assign each of its digital name. For the digital interface, we can receive data on the consumption of current and temperature of each thruster.

Thruster consists of three important components:

- brushless motors with a working voltage of 48 volts.
- power management system that regulates the power and direction of rotation
- hull-screw system that provides electronic seal and the necessary hydrodynamic qualities.

Video system

Figure 9 - Camera

The video system is one of the most important parts of the ROV, so it has been given to a lot of attention. The main requirements to the video system are: reliability, stability (noise immunity) and quality. At the general meeting of the team, it was decided that for quality and convenient performance of all tasks assigned to the machine will be only three cameras with three different viewpoints. With camera models we have not experimented and installed time tested those used in last year's machine. Cameras placed follows. Main camera - color, analog, AVC322EEM model with a resolution of 960x576, fixed to the servomotor and is located on the top front of the ROV. The servomotor allows you to change the angle of view, which is very convenient. A similar camera is installed, as well, at the front of the machine, directly on a foreshortening capture manipulator and allows the pilot to observe it from the other side. Third - aft camera, analog, black and white with a 960x576 resolution, installed for convenience of doing some missions. Now a little about the video transmission. For the comfort and quality control machine, it was decided to to display the two remote video from two different cameras simultaneously. The problem is that the main cable has only one coaxial cable in which usually only one video signal is transmitted. To solve this problem, it was decided to use the video modulator (in machine) and the demodulator (in the console). These two devices can transmit video over a single coaxial cable at different frequencies without significant losses. Thus the main camera on the line is connected to a video modulator and video from it constantly comes to console. The second video comes from a multiplexer which is connected to all three aforementioned camera. For multiplexing the video we used the chip AD8184 feeding from +/- 5V, with a consequential increase in video chip AD8009. Three millimeter coaxial cable, copes with its functions has been used to provide noise immunity video. It is worth adding that the entire video system is electrically isolated from the rest of the electronics machine. Console is equipped with a video tuner and additional video output for your TV.

Electric system

To create a compact machine, we had a good think about the electronic part of the autopilot. To control the ROV, it was decided to use the microcontroller STM32F407, this microcontroller we bought already prepared to pay to see 7h8.5 dimensions, data size and become the basis for us. In general, all electronics Autopilot placed on three boards: the board with a microcontroller TE-STM32F407, below the power board, the board with sensors and video multiplexer. In addition, the machine is equipped with a depth sensor, the PCB for processing the signals which accommodated separately. This was done to reduce electronic interference, and to obtain precise data on the depth, which is very important to perform some tasks. Depth gauge based on overpressure. Sensor based on strain gauges. The sensor signal amplifier devices, then it is digitized using 16-bit analog-to-digital converter and transmitted via the CAN interface to the main controller.

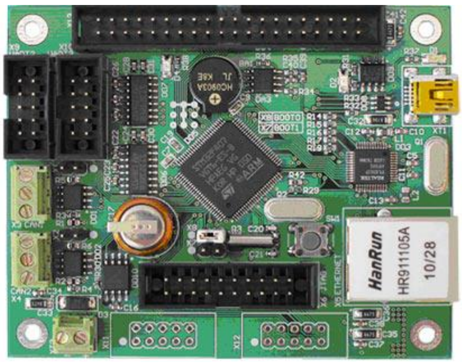

Figure 10 - PCB TE-STM32F207

- **PCB TE-STM32F207.** TE-STM32F407 - Multipurpose module Terraelektronika company formed on the basis of 32-bit microcontroller STM32F407 company STMicroelectronics. The used microcontroller has a Cortex-M4F core, two-port USB (FS and HS), Ethernet, two CAN ports. Cortex-M4F kernel includes a block floating-point (FPU), memory protection unit (MPU), implements a set of DSP-teams. The maximum clock frequency of the microcontroller is 168 MHz, the speed of the three 12-bit ADC - 2,4 MSPS (7,2 MSPS during group work). These parameters, together with the increased program memory and data provide new opportunities control and signal processing using STM32F4 microcontrollers.

- **Power PCB.** A separate PCB with DC / DC converters has been created to provide on-board power electronics. It is necessary to convert high input voltage to a lower, and also performs regulatory function, filtration and protection against interference of all kinds. Input voltage + 48V is converted to + 12V, + 5V and + 24V. Also on the PCB unit converters arranged H-bridges and logic element for controlling the manipulator.
- **Sensor PCB.** Sensors PCB is required for timely decision-making and to ensure control and security machine. Each unit is equipped with a sensor machine leakage, namely the camera, depth sensor and an autopilot. On the power PCB, each of the sensors is processed by the microcontroller and, in the case of leakage, alerts the pilot. Next sensor - navigation and piloting LSM9DS0, including a 3D gyroscope, 3D

accelerometer, 3D magnetometer. The PCB also has a sensor which measures the internal pressure of machine, providing additional control over the integrity machine. Before immersing the machine is pumped air to a certain level. This is done to compensate for the pressure difference at great depths. All the information from the sensor through the microcontroller enters the console. In addition to the sensors located on the PCB along with the Video Multiplexer amplifier and a DC/DC converter 48V - +/- 5V.

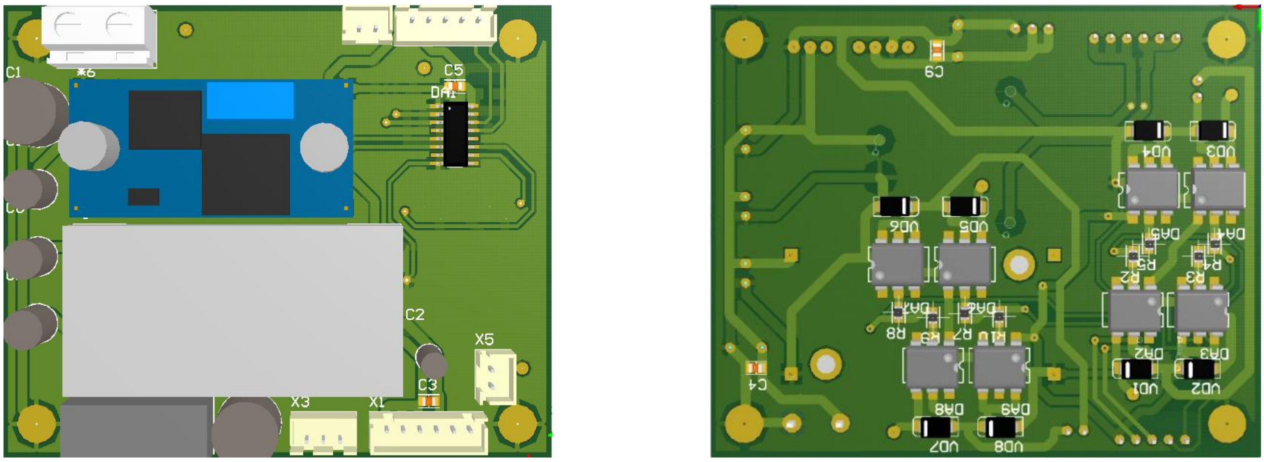

Figure 11 - Power PCB

SID (System Integration Diagram)

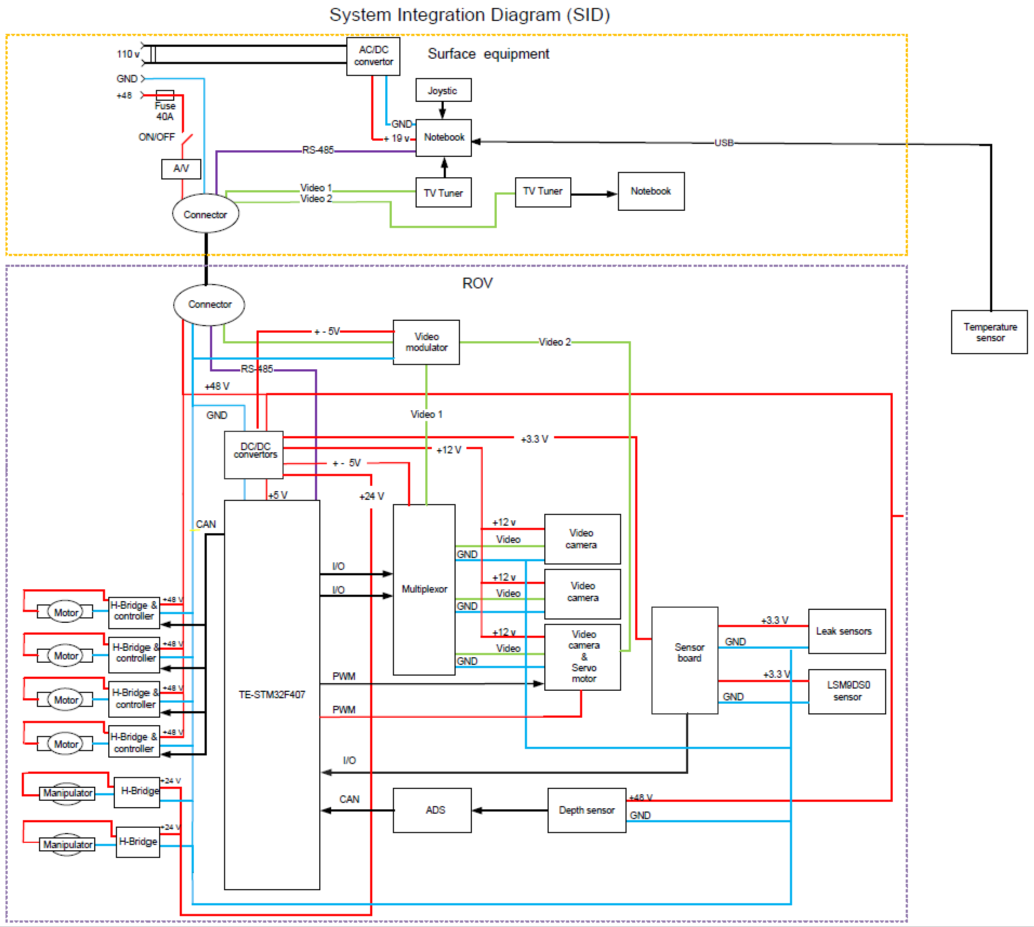

Figure 12 - System Integration Diagram

Construction of autopilot and sealed connector

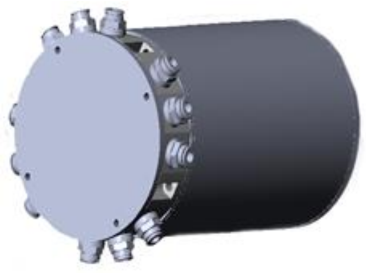

Figure 13 - Autopilot

In the previous years our team had serious problems with sealing, installation and transportation, so we decide to avoid these problems and the following decisions were taken this year:

- The material for the autopilot was selected aluminum instead of acrylic because it is not deformed during processing.
- For more convenient access to the onboard electronics was made retractable chassis on which is installed on-board electronics.
- Autopilot as in previous years is equipped with a valve for air injection which allows to detect leaks without causing damage to the electronics.
- This year it was decided to make a one junction box which is designed for twelve fittings for electronics.
- The power cable is equipped with a sealed connector which is mounted on the unit, there are three connector fitting to power onboard systems unit.

Navigation sensors

We use LSM9DS0 sensor and depth sensor gages for underwater navigating

The LSM9DS0 is a system-in-package featuring a 3D digital linear acceleration sensor, a 3D digital angular rate sensor, and a 3D digital magnetic sensor. The LSM9DS0 has a linear acceleration full scale of ±2g/±4g/±6g/±8g/±16g, a magnetic field full scale of ±2/±4/±8/±12 gauss and an angular rate of ±245/±500/±2000 dps. Sensor includes an I2C serial bus interface supporting standard and fast mode (100 kHz and 400 kHz) and an SPI serial standard interface. The LSM9DS0 is available in a plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Depth sensor consists of a strain gauge pressure sensor. The sensor signal to the amplifier, then it go to the microcontroller STM32F4 and digitized by 16-bit analog-to-digital converter is built into microcontroller. Since microcontroller the signal transmitted to the main controller by the CAN interface. The thermal resistor is embedded in system for greater accuracy in the measurements.

Communication

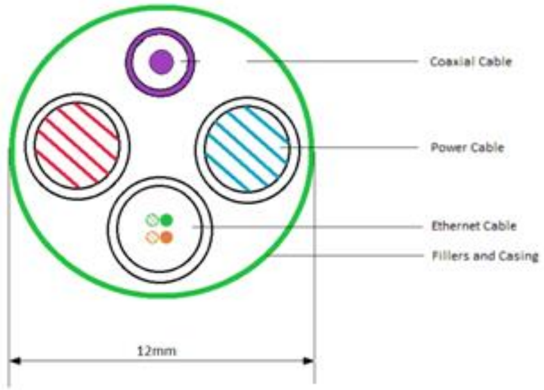

Figure 14 - Cable

Tether

We have considered mistakes of the past years and have made every effort to ensure reliable communication with this ROV. This problem was solved with electronics engineers and designers together, we have been improved connection of wires and connectors that will not bend, were hermetically sealed, and did not go down during intense work. Every detail before making was designed in SolidWorks.

ROV cable structure consists of:

- Power copper cable - section 6 mm ^ 2, for supplying power to the ROV
- Twisted pair - that is, to send a control signal to the microcontroller, and the feedback from our ROV.
- Coaxial cable - that serves as to transmit video to the surface.

For protection from moisture, we used a silicone hose with an internal diameter of 16 mm.

Switching unit

Communication with the main console is realized by the RS-232 standard via USART interface. The choice fell on the RS-232 due to the fact that it is rather simple to set up and implementation data transfer relative to other a physical level standards.

Thrusters and depth sensor to communicate with the master controller via the CAN interface. CAN was chosen because All these devices work on the basis of STM32F4 controller and CAN is primarily focused on the networking of the various actuators, controllers and sensors.

The navigation sensor communicates via SPI. SPI works in full duplex mode, which allows at any time, make queries and receive data from the sensor.

Payload

Manipulator

Figure 15 - Manipulator

For specific tasks, such as collecting samples of oil, recovery equipment, and other tasks related to the seizure of objects, we decided to use Rovbuilder companie's manipulator with two degrees of freedom. For this contact the manipulator was designed control unit, which is based on decoder 74HC139 and optorele PVG612, the choice of the scheme is conditioned by simplicity, and as a consequence, the reliability.

Manipulator's operating voltage is 24 volts . The strength of the compression arm 7.5 kg. To accomplish this, the base of the manipulator claws were replaced by larger ones with the modified geometry, with the expectation, that that they could embrace bulky object and at the same time embrace a little object.

Temperature sensor

For a long time we could not come to a common decision on the temperature sensor. Are manufactured separately from the vehicle or attach it directly to the vehicle. As a result, the first option seemed to us more comfortable. It was made sensor measures the temperature of the thermistor - AD592anz, which is placed in the enclosure, connect the wire to the ADC, which is located on the ground and connected to the USB port of the console. The housing of the sensor was made by hand and is a sealed capsule is inserted into the clip, which is securely attached to the pipe. The same was made the second version of the sensor, which was purchased from the online store, and has already included the ADC and a miniature hermetically sealed body, and has a small measurement error. It is similarly inserted into the clamp. As a result, the two sensors allow to perform with utmost precision temperature measurement.

Software

ROV remote control software

We used C++ and Qt to write Space Wolf's remote control software. This choice allows us to make software cross platform. It's works perfectly under Linux and Windows. Our software has a two modes: single pilot mode and copilot mode.

The single pilot mode designed for direct ROV control via joystick. Also single pilot mode allows to test different peripheral devices such as thrusters, cameras, LED and so on.

The copilot mode designed for complex ROV control. In this mode second pilot can enable or disable different regulators: yaw stabilization, roll stabilization, etc. Also this mode have additional window with advantech functionality. In example it has ability to take picture from cameras for future coral comparison.

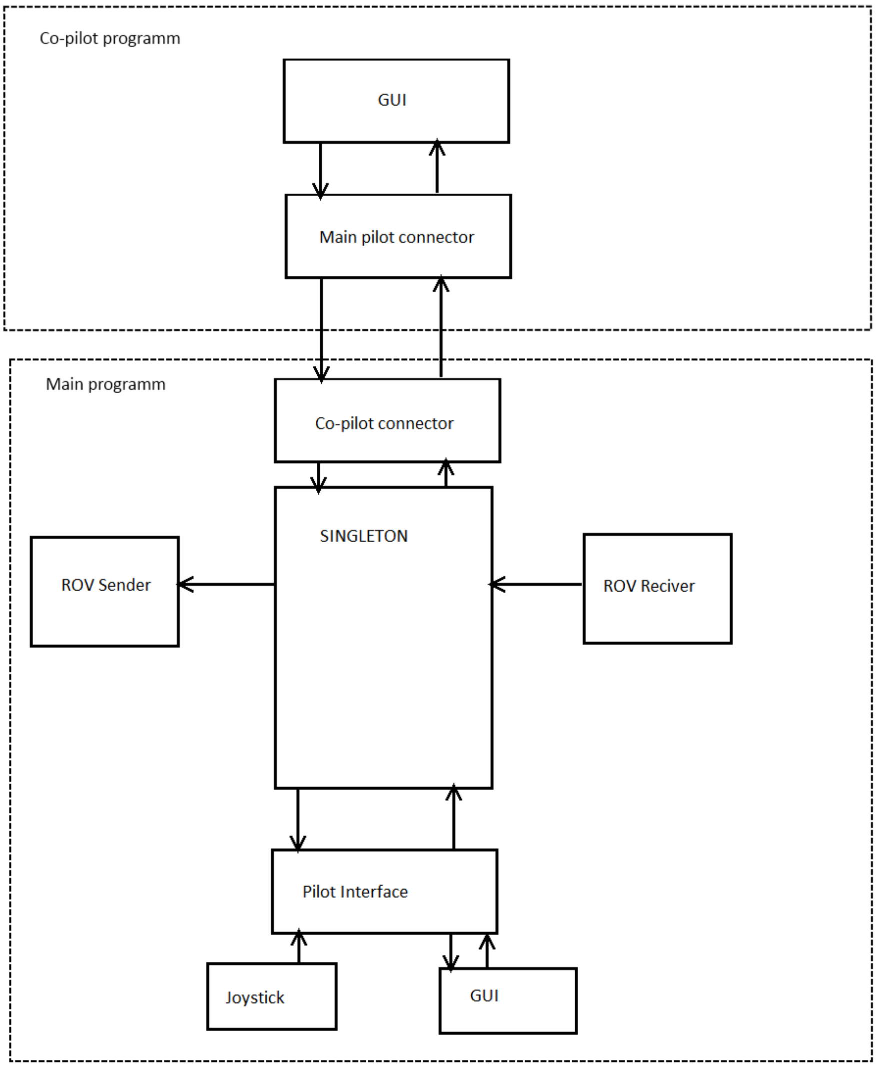

Figure 16 - Flowchart

ROV on board computer
We are using SoC TE-STM32F207 designed by Terraelectronica - russian hardware manufacture as an on board computing unit. TE-STM32F207 based on STM32F407 - ARM Cortex M4 MCU.

On board computing unit connected with surface PC via RS-232. MCU used for: thruster control, cameras multiplexing, stabilization, LED control, sensor data collection and transmitting all collected telemetry on to surface.

We are using C programming language and STM32F4xx libraries provided by STMicroelectronics for writing MCU firmware.

We are using CRC-16-CCITT with 0x1021 polynomial to prevent undefined behavior if data was corrupted while transmission

Challenges

Technical
This year, the following problems faced team

- Solve problems with encapsulation autopilot

- To design the autopilot with a junction box

- To make a detachable power cable

- Make a comfortable removable chassis

- To get into the minimal size and weight of machine

- Design claws to perform the tasks set by the organizers of the competition.

During the creation of the Space Wolf have appeared quite a lot of technical problems the plan. The most important of them was leaking autopilot camera.

This year was supposed to use last year's servomotor camera body but during the creation of the body in the air overpressure out through micro cracks. Solving the problem by means of the sealant no results, only worsened the situation so that the re-verification of the body because of the existing cracks in it burst and thereby shifted the terms the Space Wolf ready for testing.

Not Technical
Non-technical problems have been related to the fact that we did not fit within the terms indicated in the plan. Our plan was formed for a half-year before the event, and it is quite sensitive to delays. Our team is composed by two students who graduate from the university this year. They are quite difficult to combine study and robotics, due to the fact that they should prepare for the state examination and protection of

the degree project. The whole team was decided to slightly relieve the schedule of these students from routine activities and leave the job to them only by their direction. Thus it was possible to combine study and robotics, without prejudice to the order for the other.

Troubleshooting

We took a comprehensive approach to the testing ROV for troubleshooting. Most of the tests have been conducted with mentors who helped us to test the new system and to eliminate the existing problems.

The most effective method of troubleshooting that testing all systems simultaneously as we think. This approach allows to remove the suspicious components and check the rest of the system in case of problems. After detection the problem the component can be removed for further testing or reconfiguration and passing of on-site as needed.

This method of testing allowed the team to quickly and efficiently identify the sources of problems and significantly reduce the amount of time spending on troubleshooting. This means that there was more time for device testing and implementation of new systems.

One of the major problems this year has been a problem with the software rather than with hardware as usual. We have a cross-platform software, and if the Linux version worked fine, the version for Windows crash in a few minutes of work.

Monitoring of program resources identified a memory leak, but it was not clear where the leaked memory, and why only on Windows, because the source code in both versions of the program was the same. Standard in our team tool for detecting memory leaks "Valgrind", integrated with Qt IDE, showed nothing.

After some downtime, it was decided to arrange a meeting with participation of both the programmers and the mentor. After brainstorming with rewriting some controversial parts of code, we became disconnected the program modules from the compilation step by step for the detection of problem. so we found the module works with a joystick, which used external library SDL. This module was launched as a standalone program, its code was extremely simplified. It was found that the challenge of one of the functions of SDL leads to leakage.

Future improvements

Future changes in the ROV's construction aimed at improving the reliability and ergonomics. Every year a team gets a step higher in their knowledge, and this allows us to use more complex technical solutions. We plan to realize the exchange of data between the ROV and console via optical fiber. The optical systems provide high quality video images and a reliable connection without loss, but require careful attitude to yourself and experience in working with optical communication channels. This year we have already conducted several experiments, but decided that it is not ready to work with such a "gentle" equipment. Also we will be work at design of the device, taking into account not only the functional quality, but also the beauty and the overall concept, because a beautiful machine is easier to sell to a potential buyer. Most companies producing complex technical equipment, great attention is paid to good design and we will attain to the level to the best in this business.

Lessons learned

Technical

For the 2016 competition of the Maritime State University team showed a simpler approach to the development of machine, and take into account the lessons of past years concerning the sealing of the autopilot. The lesson was taken into account last year. Last year, in the processing of acrylic tube acrylic tube he was deformed and became ellipsoid and so this year it was decided to make the autopilot is completely made of aluminum and it is possible to eliminate the flow of the autopilot and the influence of external factors on the reliability of the autopilot.

Last year, the power the autopilot power cable has been soldered to the autopilot chassis and this caused inconvenience during transport and mounting PCB so the decision to make a separate sealed connector was made this year for the power cable for convenient mounting transportation and whistle to zero the impact of human exposure to autopilot.

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..

Reflections

Vladislav Kutsenko

Behind my first year that I am a member on the team I managed to get along with the team and make new friends, learned to to use knowledge in practice by working as a team, I realized that a serious project requires a serious attitude to everything: careful design of individual parts and components with complex SolidWorks software. I want to thank the Maritime State University and Center for development of robotics for the opportunity to participate in this project, as well as mentors for their invaluable advice.

Aleksandr Morozov

In this project I have been involved in the role of design engineer for the second time. It is thanks to this project, I learned a lot, learned to apply their knowledge in practice, also tried to take into account the errors of the past year. I learned a lot about the construction of underwater robots and materials from which they are made. Working as a team, I realized that a serious project requires a serious attitude to everything: careful design of individual parts and components using sophisticated software such as the SolidWorks, development and search for solutions to complex engineering problems. And the most important and valuable experience that has been obtained by me during the participation in the project - experience of working in a team of associates who share a common goal - to create the best ROV.

Teamwork

We knew what teamwork is the key to good result. That is why all processes from design to manufacturing was planned. Each team member must stick to the plan.

The plan involves the presence of four groups - software engineers, electrical engineers, contractors and mechanics. Each group have its own advisor.

We had team meeting every week, so every member of our team was informed about progress of other members.

This system allows us to use our skills and knowledges extremely effective.

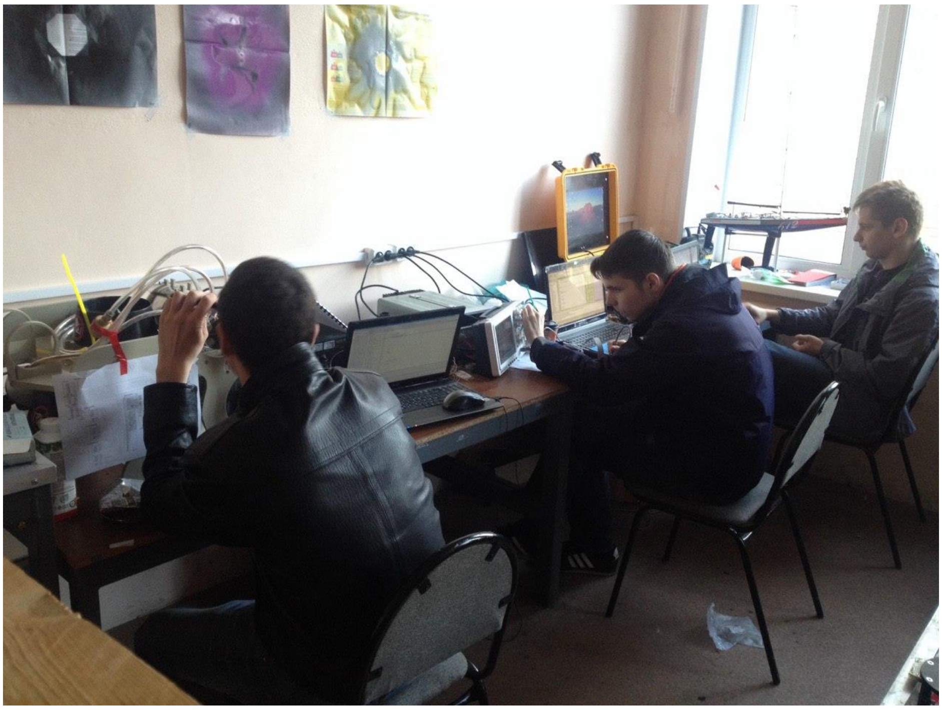

Figure 17 - Team in working process

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