Bauman Moscow State Technical University

Moscow, Russia

Explorer class

Technical Report

2010 MATE International ROV Competition

ROV AKVATOR

Bauman Moscow State Technical University

Team members

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Team mentor

Stanislav Severov, PhD, Professor of Bauman Moscow State Technical University

Abbreviations

APC – Active Propelling Complex

BMSTU – Bauman Moscow State Technical University

CAD – *Computer-aided design*

DC – direct current

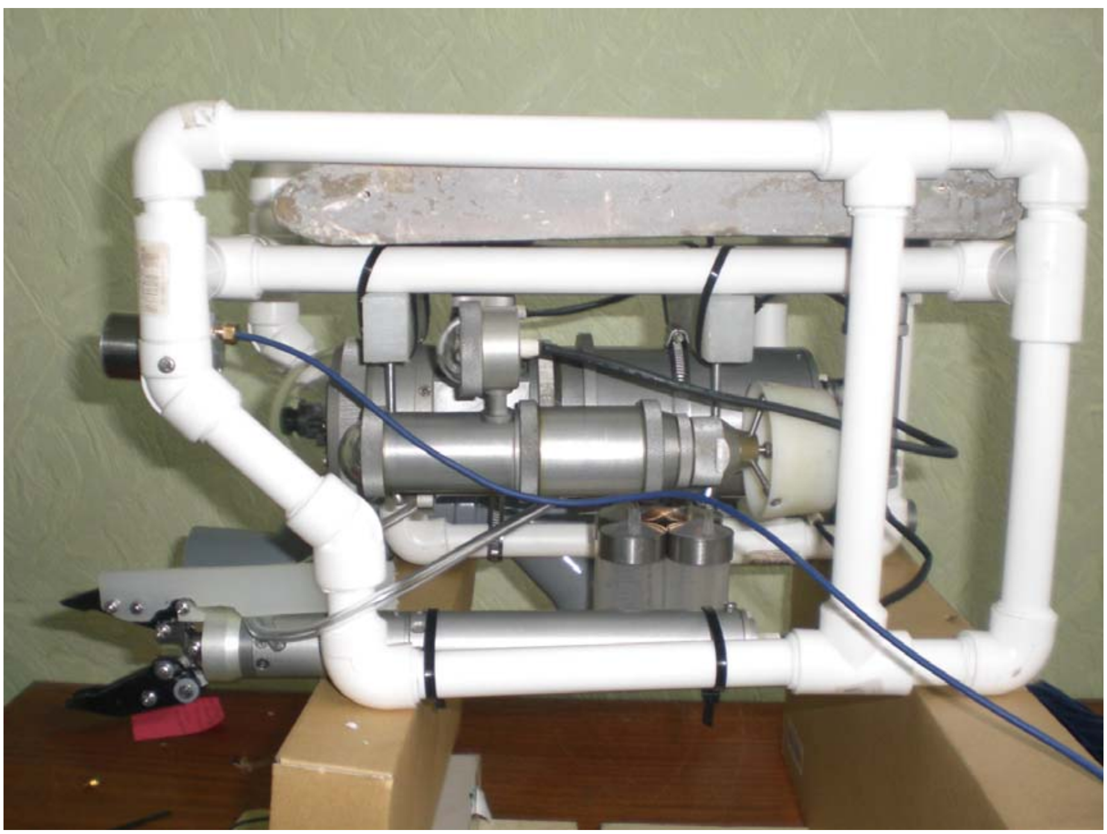
FEBRAS – Far Eastern Branch of the Russian Academy of sciences

MATEC – Marine Advanced Technology Education Center

PAP – Package of Applied Programs

ROV – Remotely Operated Vehicle

Photos of ROV Akvator



Abstract

The report describes ROV "AKVATOR" created by the student team "Hydronautic ROV" of Bauman Moscow State Technical University to perform the missions of International Competition MATEC-2010.

The ROV chassis base is a polypropylene frame. The pressure hull and the propulsion system are attached to it. The propulsion system is based on 8 thrusters of MAXON Company (Switzerland). Quantity of thrusters and their mounting arrangement give an opportunity to control the ROV at all 6 degrees of freedom. Such maneuverability is connected with small dimensions of the vehicle and inability of installation of a complicated (heavy) manipulation complex.

Taking into account the vehicle maneuverability, a one- (two) degree-of-freedom manipulator and special extra equipment (for 4th mission performance - described below) are enough to accomplish all the missions of MATEC-2010. The control system provides vehicle handling both in manual and semiautomantic (with one or several coordinate fixation) modes. The video system consists of a rotatable high resolution camera and an additional camera for a special mission performance. The average project cost, which includes development expenditures, vehicle building and participation expenses, doesn't exceed sums spent by competitive teams (even taking into account donated materials and components cost).

Table of Contents

Budget

BMSTU ROV TEAM EXPENSE REPORT AS OF 9/11/09

Бюджет проекта создания аппарата и участия команды Аква ТОР МГТУ в международных соревнованиях подводных роботов

Item Description	Source	Donated	Cost
Travel Stipends	BMSTU	$	$ 18000-
Fiber Optic Video Link	SIO RAS	$ 5,050	$ -
Main Camera & Housing	SIO RAS	$ 3,000	
25 Student Versions of SolidWorks	Dasso Systems	$ 2,500	$ -
Thrusters (5)	SIO RAS	$ 1,937	$
Printed Circuit Boards	SIO RAS	$ 1,485	
Underwater Connectors	SIO	$ 908	$ -
Foundation Grant	BMSTU	$ 700	
Rapid Prototype Camera Housings	TETIS	$ 550	
Tether	EDBOERAS	$ 550	
Waterjet Services	TETIS	$ 500	$ -
LED Lamps	EDBOE RAS	$ 360	
IP68 Rated Cabling & Connectors	SIO RAS	$ 350	$ -
Plastic & PVC sheets	TETIS	$ 300	$ -
Aluminum Hard Anodizing	EDBOE RAS	$ 300	
16 ea PIC18F4431 Processors	BMSTU	$ 132	
Acrylic Tubing	BMSTU	$ -	$ 95.00
Batteries	BMSTU	$ -	$ 76.00
CNC work for aluminum parts	EDBOE RAS	$ 27-	$ -
Electronic Components	BMSTU	$ -	$ 375.86
Fiber Optic Cable	SIO RAS	100$ -	$ -
Foam Float Material	BMSTU	$ -	$ 125.00
Misc Supplies	BMSTU	$ -	$ 276.00
Motors (2)	BMSTU	$ -	$ 15.50
O-Rings, shaft seals & sealant	EDBOE RAS	$ -	$ 35.75
Pulleys and cog belts	BMSTU	$ -	$ 75.00
Salvage Parts - Hydraulics & Pneumatics	EDBOE RAS	$23 -	$ -
Salvage Parts - Video Mixer	TETIS	$45 -	$ -
Salvage Parts - Video Selector Box (2006)	SIO RAS	$34 -	$ -
Salvage Video Cameras	EDBOE RAS	$56 -	$ -
Solenoids (left over from 2006)	EDBOE RAS	$ 18-	$
Stainless Fasteners	BMSTU	$ -	$ 126.00
Travel Costs		$	$ 18000
Student input to travel costs		$ 1,500	$
Student Fundraising on Ebay		$(4,000.00)	$
Total Donations		$29,000	$ согласовать
Total Cost	согласовать		$14,200
		Total Project Cost: $ 43,200	

Electrical Schematic

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Design rationale

Frame construction

As a material of a framework there were selected polypropylene pipes of 1 inch (25,4mms) and fittings to them. Density of a material of a framework is 980 kg/м3. The shape of a framework was selected due to optimal placement of all units and systems of the ROV under condition of minimization of overall dimensions.

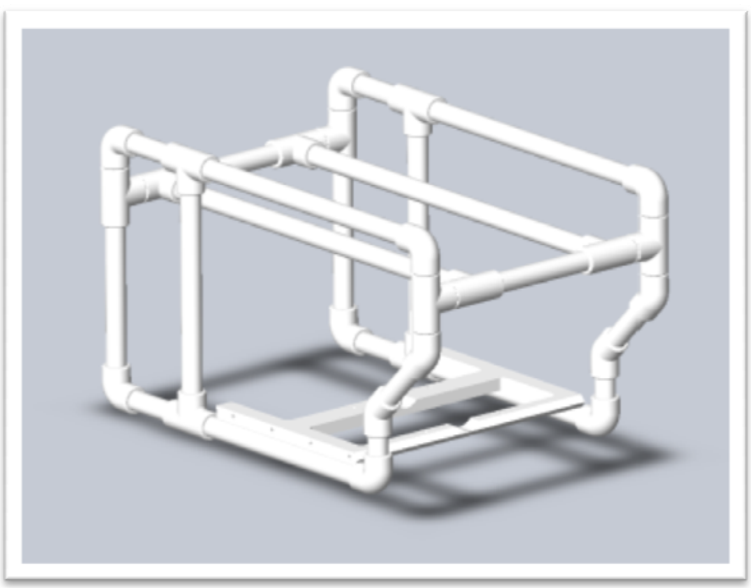

Figure . **Model of a Framework**

Vehicle systems
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Thrusters
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Video system
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Tether
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Control system

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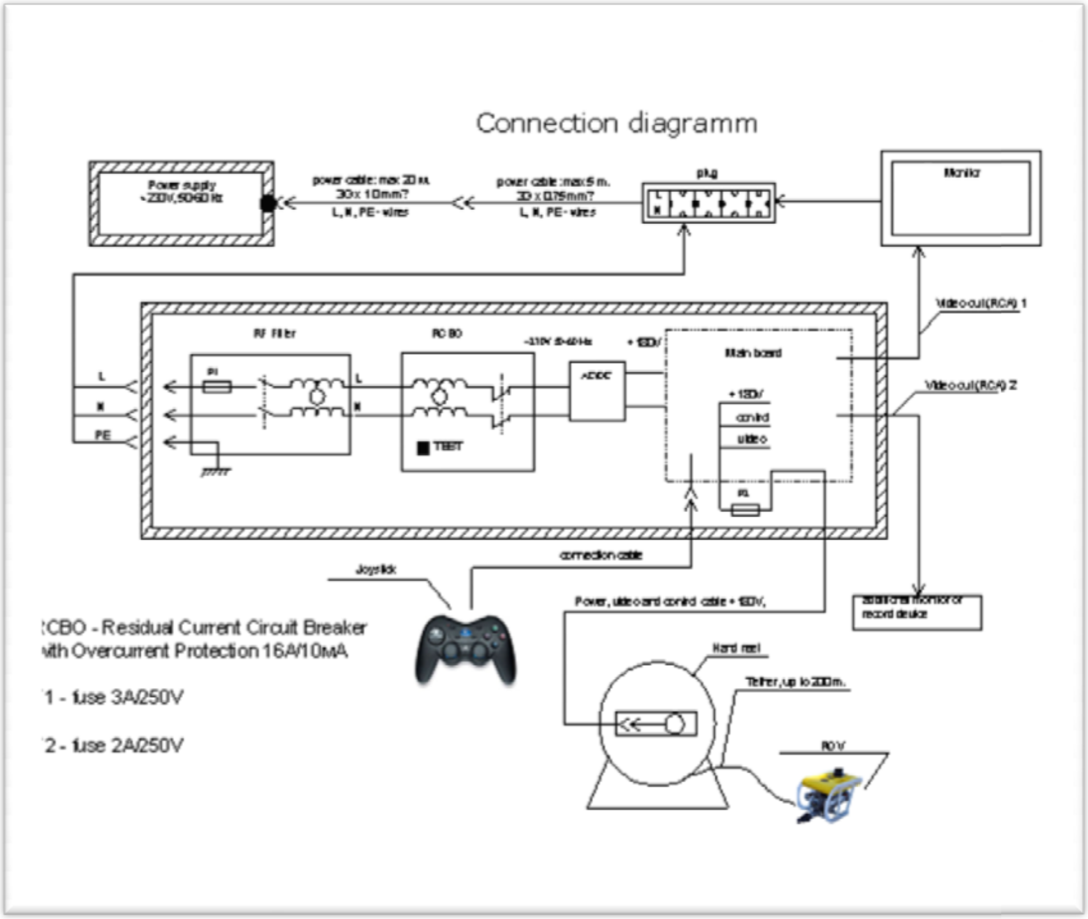

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Figure . In the process of translation from Russian to English.

Mission Objectives

Task #1: Resurrect HUGO

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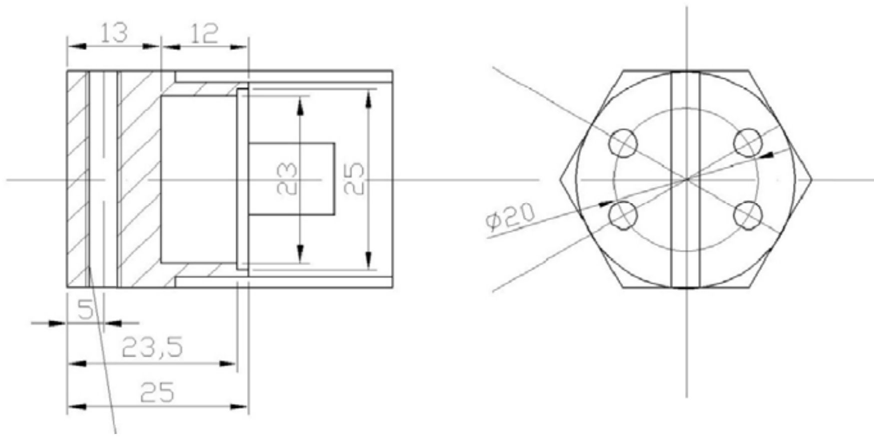
В качестве гидрофона используется обычный микрофон помещенный в гермоблок с низкочастотным фильтром, сигнал с которого по отдельному кабелю передается непосредственно на ноутбук.



Task #2: Collect samples of a new species of crustacean

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Разработано специальное приспособление для сбора ракообразных. Принцип действия: насос засасывает воду с ракообразными, которые оседают на специальной сеточке.

Figure . In the process of translation from Russian to English.

Figure . In the process of translation from Russian to English.

Task #3: Sample a new vent site

In the process of translation from Russian to English.

Для выполнения мисси было разработано специальное устройство в основе которого лежит термодатчик (MCP9804 ±0,25°C Typ. Accuracy Digital Temperature Sensor). Сигнал с датчика передается на плату, находящуюся в аппарате.

Task #4: Collect a sample of a bacterial mat

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Приспособление основано на свойстве воды – малая растяжимость.

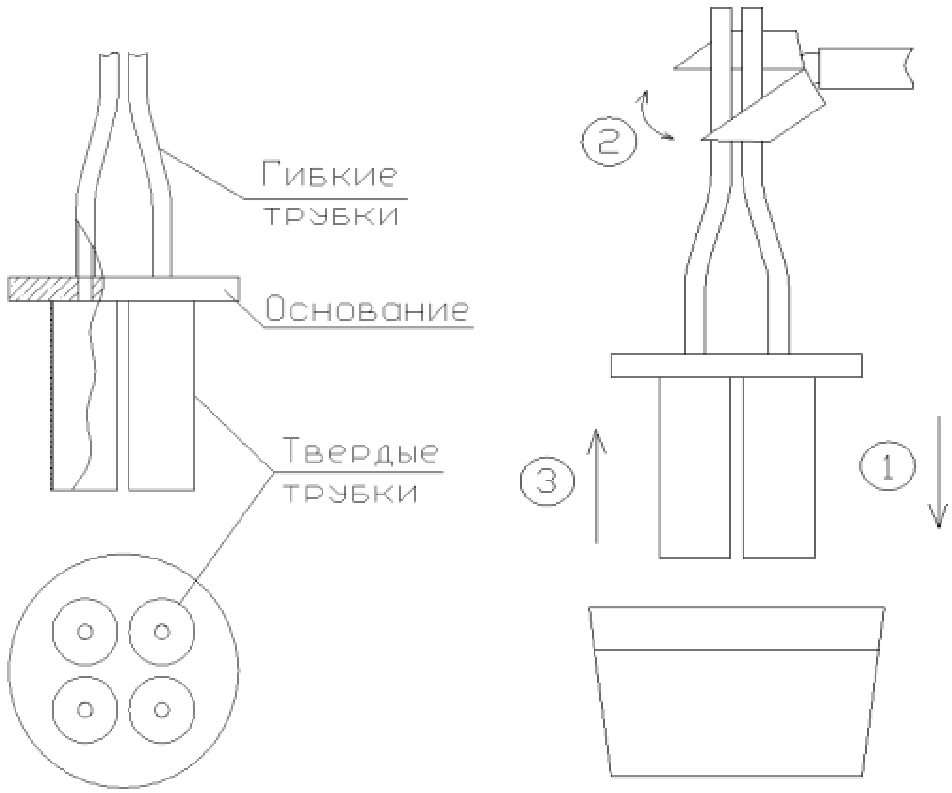

Figure . In the process of translation from Russian to English

Challenges and Problems

Designing our ROV, we have faced with a lot of difficulties, which we successfully got over. As our command was divided into groups, each of them made defined part on project.

The group of modeling has made 3D-model in one not-permitted CAD-system, so in the shortest time we had to learn new CAD-system.

The group of guys worked on building of Test ROV in the Institute of Oceanology of the Russian Academy of Sciences has faced with a range of difficulties: starting from deficit of components, finishing with mistakes made through lack of attention, which caused hours-long diagnostic events.

Troubleshooting Techniques

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Payload Description

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Future Improvement

This is the first time when we take part in MATEC competition, and we succeed in designing and building of worthy ROV. By the next competition we are going to make our system modular and to turn repairing of possible malfunctions to adding a suitable standard module.

Also we'll do our best to design improved manipulator for easier mission completing.

Lessons Learned

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Loihi seamount

The bulk of information about Loihi comes from dives made in response to the 1996 eruption. In a dive conducted almost immediately after seismic activity was reported, visibility was greatly reduced by high concentrations of displaced minerals and large floating mats of bacteria in the water.

Figure The HUGO junction box almost ready to be retrieved from the ocean floor. The box monitored activity on Loihi Seamount

In 1997, scientists from the University of Hawaii installed an ocean bottom observatory on the summit of Loihi Seamount. The submarine observatory was nicknamed HUGO, (Hawaii Undersea Geological Observatory). HUGO was connected to the shore, 34 km away, by a fiber optic cable. It gave scientists real-time seismic, chemical and visual data about the state of Loihi, which had by then become an international laboratory for the study of undersea volcanism. The cable that provided HUGO with power and communications broke in October 1998, effectively shutting it down.

It was highly desirable to visit the HUGO Junction Box to perform the following tasks:

1. Cut off the anchor cable
2. Adjust the attitude of the Junction Box if necessary and survey the area, remove the Power Regulator connector to see if the system begins operating again.
3. If so, test all optical and electrical circuits in the HUGO connectors with a new test connector designed to evaluate all connector functions
4. Replace the High-Rate Hydrophone with a new unit, and return the other to the surface, deploy the sea-water return electrode
5. Return the Experiment module to the surface and replace the connector and cable to the experiment package, then return the unit on the following dive and re-install it.
6. Install a new connector designed to allow voice conversation between the submersible and HUGO Shore Station via acoustic link.
7. Attach the Power Regulator Module and connector to the Junction Box float and release the float to be picked up by the Kaimikai-o-Kanaloa.

On January 19 of the following year, HUGO was visited by Pisces V. Methods to prevent the leaks in the connectors were tested and two new hydrophones, a test connector, and experiment connector –cable were built up. Four dives were planned to accomplish the above tasks and to attach cable protection to the main cable at "hard spots" where it shows attenuation near shore, and where it passes through very rough territory towards the north end of Loihi. The observatory functioned for four years before it went dead again in 2002.

Loihi's mid-Pacific location and its well-sustained hydrothermal system contribute to a rich oasis for a microbial ecosystem. Areas of extensive hydrothermal venting are found on Loihi's crater floor and north slope, and along the summit of Loihi itself. Active hydrothermal vents were first discovered at Loihi in the late 1980s. The two most prominent vent fields are at the summit: Pele's Pit and Kapo's Vents. These vents were considered "low temperature vents" because their waters were only about 30 °C. The volcanic eruption of 1996 and the creation of Pele's Pit changed this, and initiated high temperature venting; exit temperatures were measured at 77 °C in 1996.

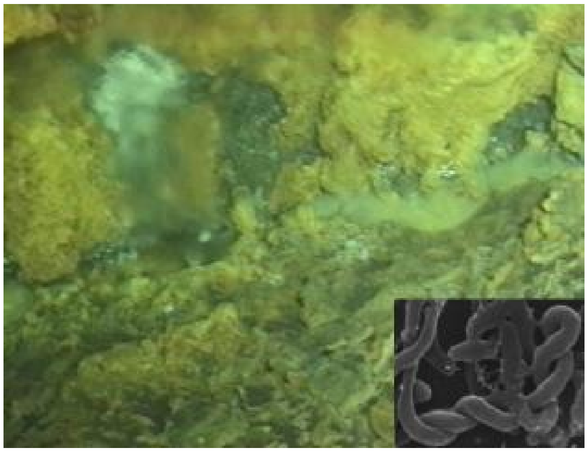

Figure Bacterial mat on a 160 °C vent. Inset shows micrograph of bacteria

The vents lie 1,100 m to 1,325 below the surface, and range in temperature from 10 to over 200 °C. The vent fluids are characterized by a high concentration of CO2 and Fe (Iron), but low in sulfide. Low oxygen and pH levels are important factors in supporting the high amounts of Fe (iron), one of the hallmark features of Loihi. These characteristics make a perfect environment for iron-oxidizing bacteria, called FeOB, to thrive in.

Figure Pisces V operated by NURP's Hawaii center dives to 2000 m

A diverse community of microbial mats surround the vents and virtually cover Pele's Pit. The Hawaii Undersea Research Laboratory (HURL), NOAA's Research Center for Hawaii and the Western Pacific, monitors and researches the hydrothermal systems and studies the local community. The National Science Foundation (NSF) funded an extremophile sampling expedition to Loihi in 1999. Microbial mats surrounded the 160 °C vents, and included a novel jelly-like organism. In 2001, Pisces V collected samples of the organisms and brought them to the surface for study.

Figure Bresiliid shrimp (Photo courtesy of Verena Tunnicliffe)

Marine life inhabiting the waters around Loihi is not as diverse as life at other, less active seamounts. Fish found living near Loihi include the Celebes monkfish (Sladenia remiger), and members of the Cutthroat eel family, Synaphobranchidae. Invertebrates identified in the area include two species endemic to the hydrothermal vents, a bresiliid shrimp (Opaepele loihi) of the family Alvinocarididae (described in 1995), and a tube or pogonophoran worm. Dives conducted after the 1996 earthquake swarms were unable to find either the shrimp or the worm, and it is not known if there are lasting effects on these species.

Reflections

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Основным фактором успеха в реализации нашего проекта бала правильная организация труда. Каждый член команды занимался по возможности тем, чем он хотел, а не тем что от него требовали. Были сформированы «группы по интересам» и выделены связующие звенья. В целом команда старалась придерживаться процессного подхода в соответствии с международным стандартом PMBOK по управлению проектами.

Photos

Teamwork

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Acknowledgements

A number of institutions have enthusiastically contributed to creation of AKVATOR:

1. Far Eastern Branch of the Russian Academy of sciences Institute of Marine Technology Problems - technical consultations, advices about organization, warnings about possible mistakes, peer reviews, participation in trial design testing.

2. Russian Academy of Sciences Experimental Design Bureau of Oceanological Engineering - expressed willingness to share with us components, laboratories, instruments and other services for creation of AKVATOR. Here, according to MATEC conditions, our team was interested in small ROVs, which meet dimension requirements of MATEC. Russian Academy of Sciences Experimental Design Bureau of Oceanological Engineering deals with larger ROVs.

3. Close corporation "TETIS" - gave us testing equipment, components, consultation and other services. Only consultations about Seabotix manipulatior turned out to be practically valuable (in minimal degree).

4. Institute of Oceanology of the Russian Academy of Sciences - possesses the most valuable, from students' point of view, prototype. AKVATOR was created by developing of this prototype.

5. An essential influence on AKVATOR project was exerted by: Underwater Robotic Systems department, Special Machine-Building faculty and BMSTU in the person of its president of BMSTU I.B.Fedorov and in the person of chancellor A.A.Alexandrov.

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