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ТРУДЫ PROCEEDINGS



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Труды 11-й Международной конференции и выставки по освоению ресурсов нефти и газа Российской Арктики и континентального шельфа стран СНГ (RAO / CIS Offshore 2013). 10-13 сентября 2013 года, Санкт-Петербург — СПб.: ХИМИЗДАТ, 2013. — 590 с.

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SAFETY OF MARITIME OPERATION AND SUSTAINABLE INDUSTRIAL DEVELOPMENT IN THE ARCTIC (SMIDA)

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СМИДА – научно-образовательный норвежско-российский проект, финансируемый Норвежским центром международного сотрудничества в области образования. Основная цель – развитие фундаментальных и прикладных знаний, необходимых для устойчивого развития Арктического шельфа и прибрежных технологии. Проект направлен на обмен студентами на уровне магистров/аспирантов, развитие связей между академическим и административным персоналом, синхронизацию процедур обучения в обеих странах и организацию совместных полевых и лабораторных работ на Шпицбергене и в Российской Арктике. Области исследования – гидрология арктических морей, физические и механические свойства льда и мерзлого грунта; береговая эрозия и вечная мерзлота, воздействие на окружающую среду производственной деятельности на Крайнем Севере, Арктические морские сооружения.

Норвежские партнеры проекта – Университетский центр на Свальбарде (ответственное учреждение); Норвежский университет науки и техники. Российские партнеры – Московский Физико-технический институт (главный партнер), Санкт-Петербургский государственный политехнический университет, Московский государственный университет (Географический факультет) и Государственный морской технический университет (Санкт-Петербург).

В ходе полевых работ и преподавания создается и испытывается уникальное оборудование, разрабатываются новые приёмы и методы, получаются оригинальные результаты, характеризующие физико-механические свойства льда, ледовые нагрузки на сооружения. Полевые работы и исследования включают тесты на припае, рейсы на научно-исследовательских судах во фьордах Шпицбергена и Баренцевом море. Сотрудничество имеет более чем 15-летнюю историю. Более 60 студентов из ведущих институтов России (МФТИ, МГУ, СПбГПУ) были вовлечены в сотрудничество и получили бесценный опыт работы в Арктике и исследования морского льда. Они работают сейчас в компаниях, университетах и научных учреждениях.

ABOUT SMIDA PROJECT

Safety of Maritime operation and sustainable industrial development in the Arctic (SMIDA) is one of 8 projects, supported by Norwegian Centre for International Cooperation in Education (SIU) in 2012. SIU is a public Norwegian agency promoting international cooperation in education and research. SIU is funded through assignments from the Norwegian Ministry of Education and Research; the Norwegian Ministry of Foreign Affairs; the Norwegian Agency for Development Cooperation; the Nordic Council of Ministers; the Commission of the European Community; Norwegian Directorate for Education and Training.

Periodically SIU organizes a scientific Norwegian-Russian exchange program on higher university education. The previous program worked in 2008-2011 years. Within that program UNIS was responsible institution for the project «Safe loading and transport of hydrocarbons from the Barents Sea» SafeLOT. The current project SMIDA is inheritor of SafeLOT. SMIDA has project number: CPRU-

2011/10042; project period: 2012-2015; funding: 4000 kNOK; Responsible institution: The University Centre in Svalbard.

The aim of the project is to develop the educational and research cooperation between Norwegian and Russian Universities to increase the basic knowledge required for sustainable development of Arctic offshore and coastal Technology. Project partners and their responsibilities are shown in the Table 1.

The project study is focused on the regions of offshore and coastal development in the Barents and Kara Seas. Main activities within the projects are the teaching and exchange of MSc/PhD students, development of communications between academic, technical and administrative staff, synchronization of the teaching procedures in Norwegian and Russian Universities and organizing of joint field works in Svalbard and the Russian Arctic.

The objective of the project is the development of educational and research cooperation between

Norwegian and Russian Universities. The focus is increase of basic knowledge of physical and mechanical processes and models influencing and used for design and support of offshore and coastal structures and ice resistant ships in the Arctic.

The project aims in particular towards sustainable development of the exploitation of petroleum resources in the Barents and Kara Seas. Basic knowledge will be communicated to students through lectures, laboratory and field works in the areas of industrial activity in the Arctic.

The project is also focused on collection of necessary experience and knowledge for young specialists planning to work in industrial companies involved in offshore and coastal development in the Arctic. Joint elaboration of new lecture courses in Norwegian and Russian Universities involved in the project and joint educational processes will improve the understanding and professional relationships between Norwegian and Russian companies and specialists working in the Arctic. The educational activity are organized at the base of the courses of the Arctic Technology Department at UNIS in the cooperation with NTNU, MIPT, SPbSPU, MSU and SMTU.

The 3 different cycles (BSc, MSc, PhD) of education including the description of Learning Outcome are implemented at UNIS. When UNIS cooperate with professors, researchers and students from Russia, they get improved knowledge about the European education system established through the Bologna process and all of the partners make mutual efforts to adapt and be able to cooperate. It also gives the students extended knowledge about the systems

of education of the different institutions, and our experience is that these students and researchers pass on this knowledge to improve the possibility for further exchange.

The main activities of the SMIDA project are

1. Teaching and exchange of master and PhD students;
2. Research cruises with student groups on research vessel *Lance* (Norway) in the Barents Sea and on Russian research vessels (*Ivan Petrov*, *Professor Molchanov*) in the Russian Arctic;
3. Field works on land fast ice in the Isfjord and van Mijenfjord, Spitsbergen
4. Field works in coastal zones of the Russian Arctic (Pechora Sea, Yamal)
5. Field works around industrial areas in Spitsbergen (Longyearbyen, Svea, Barenstburg, Pyramiden).
6. Modeling, numerical simulation and software development.
7. Creating of information environment and geographical information system. The project focuses on the following research directions:
 1. Physics and mechanics of ice
 2. Physics and mechanics of frozen soils
 3. Hydrodynamics of ice covered waters
 4. Physical environmental actions on Arctic coastal structures
 5. Ice loads on offshore structures/ships and effects on marine operations

Table 1. SMIDA conceptual scheme

Institution full name and location	Acronym	Responsibilities in the SMIDA project
The University Centre in Svalbard, Longyearbyen, Norway	UNIS	Project management, economy and logistic support. Workshops and meeting. Lecturing, field and laboratory works. Modeling of ice processes and numerical simulations. Software development. Project web-page on UNIS web-site (English version). Design of information environment for the project
Norwegian University of Science and Technology, Trondheim, Norway	NTNU	MSc and PhD students. Lecturing. Software development.
Moscow Institute of Physics and Technology, State University, Russia	MIPT	Modeling of basic physical processes, related to ice/water loads on structures and coastal zone. Creating and maintain the informational environment for the project; Project web-page on MIPT web-site (Russian version). MSc and PhD students.
Lomonosov Moscow State University, Russia	MSU	Field study of coastal erosion and permafrost degradation. Human impact assessment. Ice mechanics. MSc and PhD students.
St.-Petersburg State Polytechnic University, Russia	SPbSPU	Modeling of ice-structure interaction Field and Lab experiment. Software development. MSc and PhD students.
State Marine Technical University of St.-Petersburg, Russia	SMTU	Instrumentation development. Modeling of ice-ship interaction Field and Lab experiment. MSc and PhD students.

6. Coastal erosion and ice actions on seabed
7. Instrumentation for advance field and laboratory measurements

HISTORY OF COOPERATION

There were more than 60 students from Russia, involved in cooperation program and studied at UNIS. We decided not to give the names of the students in this article. One can find the names, photos, e-mail and current affiliation on the SMIDA web-page presented on UNIS web-site in ALUMNI section.

The Norwegian-Russian collaboration in the field of Arctic Technology (AT) has more than 15 years history. In 1995 NTNU received a grant from the Central and East-European Programme that was dedicated to network building with leading institutions in Arctic Technology. The project leader was Prof. Sveinung L set. The main partner for NTNU was the department of Offshore and Waterways Structures of St. Petersburg State Technical University (SPbSPU), that had already experience in collaboration with western institutions and they had basic knowledge applicable to the estimation of physical environmental loads on offshore structures. The major contact person at SPbSPU was Prof. Karl Shkhinek.

The 2 first students came to UNIS from SPbSPU in autumn 1996, just three years after UNIS was established in 1993 to provide university level education in Arctic studies. 22 students from SPbSPU had been studying at UNIS in the period 1996-2006. Several common publications, including the book in Russian and English had been prepared [1, 2, 3, 4].

Since 2006 UNIS Prof. Aleksey Marchenko has involved into cooperation the Moscow Institute of Physics and Technology (MIPT). In 2008-2010 UNIS hosted the SIU project «Safe loading and transport of hydrocarbons from the Barents Sea» (Acronym: SafeLOT), that allowed

to support more Master Students, one PhD student at SPbSPU, who was external PhD at UNIS and performed field and lab experiments on Svalbard and one PhD student, constantly located at UNIS.

Students from Moscow State University attended UNIS courses since 2009. In 2012 there were 2 students from Moscow State Academy of Water Transport (MSAWT) and 2 students from SMTU came for the first time in Spring 2013. One can see the dynamics of quantity of Russian students at Arctic Technology departments at UNIS over 17 years on Fig. 1.

Russian students, studying at UNIS had the financial support from SafeLOT project (SIU) in 2008-2011 or from the other SIU program called «Nordomr de stipend» (The fellowship program for studies in the High North). Now they have SMIDA support or Nordomr de stipend»

Several students continued study in Norway as PhD students, some of them work at the oil related companies over the world.

RELATED PROJECTS

SMIDA works in close cooperation with the Centre for Sustainable Arctic Marine and Coastal Technology (SAMCoT), SAMCoT is A Centre for Research-based Innovation (CRI), supporting long-term research through close cooperation between R&D intensive companies and prominent research institutions. The research activities in SAMCoT are carried out by the host institution NTNU together with UNIS, SINTEF and 14 other partners. SAMCoT belongs to a group of seven new centres which were appointed by the Research Council Board on 16th December 2010.

SAMCoT started its activities on the 1st of April 2011 and is expected to operate until 2019. SAMCoT has

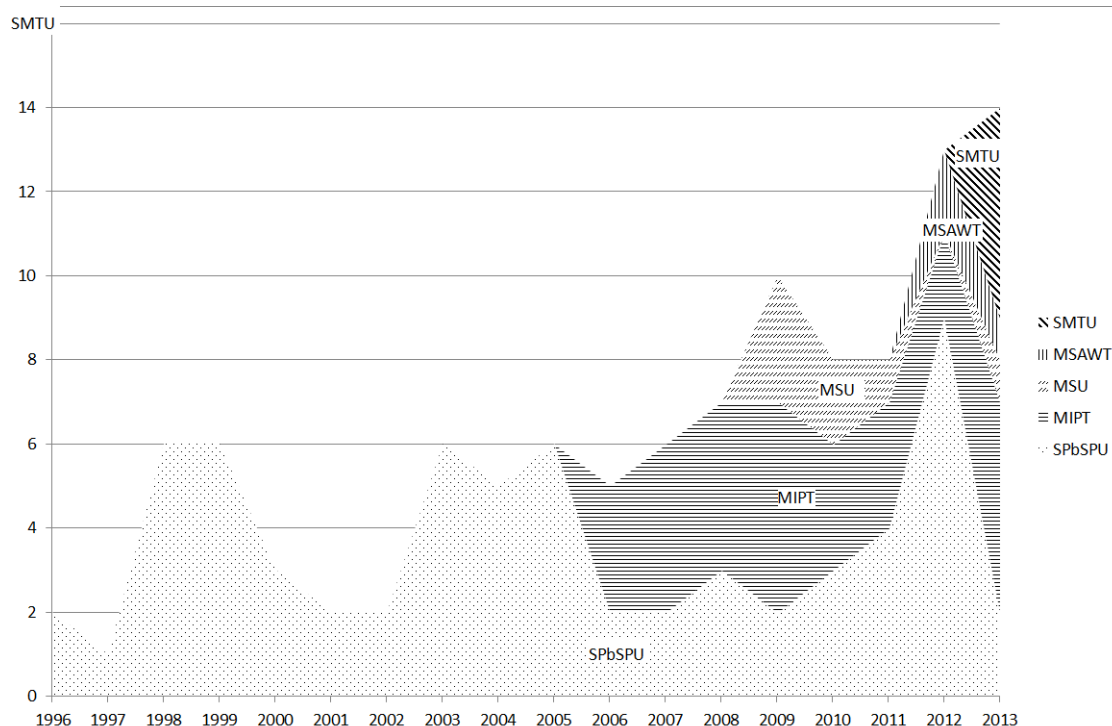


Figure 1. The Amount of Russian students from different Institutions at UNIS (Arctic Technology Department) through the years (for Autumn 2013 – estimation, according to accepted applications)

turnover funding 25 Mln NOK per year and accumulate over 8 years 200 Mln NOK.

Collaboration with SAMCoT allows SMIDA to obtain and use cutting-edge scientific equipment such as 3D Laser Scanner, original equipment for ice strength tests and oceanographic measurements (indentors, load cells, stroke sensors, ADCP, CTD, ADV), fibre optic sensors.

Educational and research cooperation with SMTU has been supported by the BP Visiting Professorship Program for teaching one 30-hour course «Ice Mechanics» in Fall 2011 (it had been fulfilled in December 2011), supervising 2-3 PhD candidates in Fall 2011 and Spring 2012, establishing cooperation with the UNIS and SMTU (the agreement had been signed in December 2011).

UNIS research cooperation with SMTU has been supported through 5 field expeditions on land fast ice in Spitsbergen for studies of ice strengths (visitors of E.Karulin and M.Karulina) by Research Council of Norwegian (RCN) via project «Physical-mechanical properties of sea ice and influence of ice cover on hydrology of Svalbard fjords» (2010-2012) [5].

In the Russian federal target program «Scientific and scientific-pedagogical personnel of innovative Russia» for 2009-2010 in collaboration MSU (S. Ogorodov) - UNIS (A. Marchenko) research work on the lot, «Conducting research teams under the leadership of visiting researchers in the field of earth sciences, ecology and environmental management» were carried out. The title of the project was «Assessment of the intensity of the dynamic effects of sea ice and icebergs to the shore, bottom and surface facilities of the Arctic shelf». As a result of this work PhD thesis was defended in Moscow State University (Russia) by O. Kokin, who was also UNIS student in 2008-2009.

Research cooperation with MIPT had funding from the Russian Foundation for Basic Research (RFBR). There were RFBR projects «Dynamics and physical-mechanical properties of Arctic sea ice» (2008-2010), Organization and carrying out of complex studies of sea ice cover in the Western Spitsbergen fjords (2009), Influence of thermo-physical properties of sea ice and sea water on the state of Arctic ice cover and energy exchange in polar regions (2011-2013).

UNIS ARCTIC TECHNOLOGY COURSES

The Arctic Technology courses offered at UNIS are especially designed for today's industrial challenges in High North including priority aspects of climate change, as the courses have the advantage of being taught in an Arctic environment where this type of technology has been applied for many decades. At UNIS students conduct field activities implemented in actual research projects. Full description of courses could be found on UNIS web-site.

There are 2 bachelor level courses in spring semester AT-205 Frozen Ground Engineering for Arctic Infrastructure (15 ECTS), and AT-211 Ice Mechanics, Loads on Structures and Instrumentation. Spring semester begins with one-week long Safety Course to give students basic understanding of harsh Arctic Condition and teach them to survive in difficult situation, but mostly to avoid such critical situation and perform the work safety.

AT-205 gives the students an understanding of the importance of infrastructure planning and how permafrost

affects the design of structures in the Arctic. Different types of foundation and design of buildings, pipelines, roads and airfields will be presented and illustrated in lectures and during field excursions. Through lectures and field trips students are introduced to different foundation methods and their ability to satisfy the requirements from the society, learn to be familiar with geological and geotechnical methods used in characterizing frozen soils necessary for design of foundation. Field works will consist of survey of foundation methods used in practice in the Arctic, geotechnical methods in soil sampling, and snow investigation methods for evaluation of avalanche hazard. Laboratory work will focus on investigation methods in characterizing the soil and finding the parameters necessary for design of foundation. There will also be one week course on snow and avalanches focusing on snow stability evaluation methods.

AT-211 course includes laboratory work in UNIS cold laboratory and fieldwork on land fast ice. Lectures about the instrumentation organized before the field works introduce students to the equipment used for the measurements of thermo-mechanical characteristics and strength of fresh and saline ice, ice thickness measurements by electro-magnetic and acoustic methods, high frequency measurements of water temperature and sea current velocities used for the calculation of turbulent heat fluxes to the ice surfaces, measurements of internal stresses and displacements of the ice. During fieldwork the students have possibility to observe sea ice motions and deformations created by tides, wind and sea currents, observe ice actions on coastal structures and ship. They also will gain experience in working with scientific equipment in Arctic conditions. Finally, the students should be able to formulate models and do numerical simulations of sea ice behavior and ice-structure interactions and perform field and laboratory tests used for the design of offshore and coastal structures in the Arctic. The most exciting part of the course is 8 days cruise on research vessel Lance.

Autumn semester is shorter and consists of 3 MSc/PhD level courses: AT-301 Arctic infrastructures in a changing climate (10 ECTS), AT-327 Arctic Offshore Engineering, 10 ECTS, AT-332 Physical Environmental Loads on Arctic Coastal and Offshore Structures (10 ECTS).

AT-301 teaches to understand weather related geological processes and geotechnical aspects connected to planning, design and protection of infrastructures as buildings, roads, bridges and pipelines in a changing Arctic climate; the influence of climate change on natural disasters as snow avalanches and slides in rock and soils. The students get knowledge of the impact of climate change on infrastructures in the Arctic, and how to solve this expected issue; how to take natural hazards into consideration in areal planning, and how to protect infrastructures as buildings, roads, pipelines etc. against snow avalanches and slides; design of buildings and roads in snow drift areas.

At AT-327 course students acquire basic knowledge of oil and gas resources in the Arctic; develop basic understanding of ice physics and mechanics; improve skills for designing offshore structures in the Arctic. Students understand how the physical environment affects such design and how the structures respond to the environmental actions. Logistics is part

of this. The actions relate to sea ice, icebergs, marine icing and sea ice dynamics. Students will develop competence through lectures and group work related to a relevant case study.

After AT -332 course students are able to perform specified phys.-math models describing sea ice evolution over a year, sea ice permeability, bending and in plane deformations of fresh and saline ice, interaction of tides and surface waves with floating ice, ice gouging, ice behavior under static and dynamic loads, influence of sea ice on steel and concrete surfaces. They get knowledge of ISO standards and probabilistic estimates of ice loads on offshore and coastal structures; ice impact on beach and coastal structures. Very important is the Experience in modeling with Comsol Multiphysics; performing ice tests in the cold laboratory of UNIS; fieldwork in the coastal zone of Svalbard fjords in the ice free season.

SMIDA PROJECT DEVELOPMENT IN 2012-2013

Officially project has started in April 2012. Already at the end of May, Prof. Aleksey Marchenko and Prof. Sveinung Løset visited Russian Partners in St. Petersburg and in Moscow and discussed the future collaboration in the frame of the project.

In July 2012 two students, supported by SMIDA, took part in the expedition in North-West Russia for investigation of coastal erosion. Expedition has been organized by State Oceanographic Institute (Moscow, Russia). Students made tachymeterical survey and collected data for estimation of erosion rate. They got valuable experience of identifying of dangerous processes in coastal zone.

The biggest (10 persons) in UNIS history group of Russian Students participated UNIS Arctic Technology Courses in Autumn Semester 2012. 6 students represented SPbSPU, 2 – MIPT, 2 – Moscow State Academy of Water Transport (MSAWT). They took 3 courses: AT-301, AT-332/832; AT-327. 8 of them were new at UNIS and 2 students attended spring courses. 4 Russian students participated UNIS courses in Spring semester 2013. 2 students came from MSTU and It was the beginning of MSTU history at UNIS. 1 student represented MIPT and 1 – MSAWT.

The sea currents and tidal investigations and CTD (conductivity, temperature, density) profiling have been performed by UNIS AT-332 students under supervising of prof. A.Marchenko (UNIS) and guest lecturers Prof. V.Gorbatsky (Krylov Shipbuilding Research institute, St. Petersburg, Russia) and Prof. Z.Kowalik (IARC, University of Alaska, Fairbanks, USA) 1-5 October 2012 in Adventfjord. The boat equipped with ADCP (Acoustical Doppler Current Profiler) RDI Sentinel 1200kHz made several transections across the fjord during 3 days. Speed and directions of sea currents have been measured in the water layer from 0 till 20 m depth. These investigations are important for estimation on ice and water actions on port constructions and other objects of coastal infrastructure. So they are interesting not only for scientist and students, but for local community and industry.

UNIS held SMIDA workshop in 19-21 October 2012. The representatives of all SMIDA partners gathered to discuss the concrete plans for research and education in 2013 and future. There were Prof.. Sveinung L set (NTNU), Prof. Aleksey Marchenko and Dr. Nataly Marchenko (UNIS)

Prof. Vladimir Zhmur, Prof. Sergey Turuntaev, PhD student Yury Fomin (MIPT), Prof. Karl Shkhinek and Prof. Aleksandr Bolshov (SPBSPU), Prof. Alexander Frumen SMTU), Dr.Nataliya Belova (Lomonosov MSU). Rector of MSAWT Vladimir Kostin, dr. Boris Stepanov (MSAWT), Dr. Dmitry Onishchenko (VNIIGAZ) presented as invited guests.

Important work has been done in autumn 2012 for instrumentation development. It was supported by SAMCoT and SMIDA project in close cooperation with SMTU and «Maskin Klund» Storm Martens (MKLSM) company, Oslo. The new constructed rig for in-situ identational tests on sea ice consists of a steel frame, 2 double acting hydraulic cylinders of 30 T power each equipped with load cells and stroke sensors, hydraulic station with regulated flow and field computer. The new rig has been tested during field work in spring 2013 and provided new knowledge of sea ice strengths important for estimation of ice loads and design of off-shore structures and ice-resistant ships.

In December 2012 project leaders Prof. A.Marchenko, Prof. V.Zhmur and SMIDA coordinator Dr. N.Marchenko participated in SIU seminar in Stavanger (Norway).

Join expedition (supported by SMIDA and SAMCoT projects) has performed field work in March 2013, in Svea. Except SMIDA participants there were researchers from Shirshov Oceanology Institute (Moscow), mechanical-mathematical departments of MSU and the author of famous test professor emeritus Devinder Sodhi (CRREL). The tasks of expedition was field Investigation of sea ice properties, testing of the new rig, in-situ identational tests, beam test, compression-strength test; CTD, ADCP profiling, tide measurements. SMIDA PhD and MSc students got very valuable experience of real work in the Arctic under supervising of professors specializing in Arctic Technology. The only upset was extremely cold and windy weather. The temperature reached -25-30°C. After arrival to UNIS the «Svea expedition» team showed and discussed the preliminary results of the field work with focus on new equipment and techniques during special workshop.

3 Phd students worked at UNIS in spring semester. They got very valuable experience of real work in the Arctic under supervising of skilled professors. Yury Fomin (MIPT) performed experiment in the cold lab, in Advent fjord, participated in field investigation of sea ice, took the first experience of teaching the bachelor student of AT-211 course. His PhD project is «Physical effects in the boundary layers of stratified ocean». Aleksei Vakulenko (SPbSPU) took part in «Svea expedition» including testing of the new rig, in-situ identational tests, beam test, compression-strength test. Aleksey's PhD project is «The method of dynamic analysis of interaction hummocky ice formations with marine hydraulic structures». Anna Abramova (MSU) began the assessment of human impact on the environment in Arctic from evaluation of anthropogenic changing in two settlements on Svalbard – Longyearbyen and Barentsburg. In May-June She collected the snow, soil and water samples for chemical analysis in the different landscapes and territories presented different types of industrial activities.

The first part of 2013 year has finished by participating of SMIDA team in the International scientific conferences, there the results of the work have been presented. 4 SMIDA related scientists made presentation on POAC, The International Conferences on Port and Ocean Engineering under Arctic Conditions in Helsinki, Finland.

POAC began in 1971 and since then, it has been held every two years at different international venues. Over the years, POAC has been the mainstay of Arctic engineering conferences and typically attracts over 150 participants to each conference. One SMIDA researcher participated in OMAE, 32d International Conference on Ocean, Offshore and Arctic Engineering, Nantes, France.

Much attention was paid to creation and support project web-pages on web-sites at UNIS (English version) and at MIPT (Russian version) and also to the organization of the information space on the subject of arctic technology, and creating an environment of electronic communications for operational data and information exchange among the participants of the grant based on the internet portals of MIPT. Web-paged have been created in September 2012 and currently up-dated.

Software development included the elaboration of Mathematica based lectures and practical exercises in Arctic technology, using Comsol Multiphysics for the modeling sea-ice thermodynamics and ice loads on structures, using of Sesam (DNV) and Anchored Structures (SPbSPU) for the modeling of floating structures in ice conditions.

SUMMARY

Norwegian-Russian collaboration in research and education, performed by SMIDA project and supported by Norwegian Centre for International Cooperation in Education is very important for increasing of basic knowledge required for sustainable development of Arctic offshore and coastal Technology. The project develops communication between students, academic and administrative staff, helps to synchronize the teaching procedures in both countries and to organize joint laboratorial and field works in Svalbard region, Barents Sea and the industrial regions of Russian Arctic.

The field investigation of hydrology of Arctic seas, physical and mechanical properties of ice and frozen ground; coastal erosion and permafrost stability,

environmental impact of industrial activity in high North, Arctic offshore structures gives new knowledge in Arctic technology and assessment.

Along the field work and teaching the unique research equipment is created and tested, the new techniques and methods have been developed and original results on physical and mechanical properties of sea ice, ice load on construction have been obtained. Field works and study include the test on fast ice, survey on research vessels in the Svalbard fjords and the Barents Sea. The collaboration has more than 15 years history and more than 60 students from leading Russian institutes (MIPT, MSU, SPBSPU) have been involved and got invaluable experience of the work in the Arctic and sea ice investigation. They work now in companies and science.

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