Increasing the sustainability of the maritime research and training

Commodore Boyan Mednikarov, Prof.Dr.M.Sc.[1]
Captain (Navy) Kalin Kalinov, Professor Ph.D.[2]
Captain (Navy) Nedko Dimitrov, Associated Professor Ph.D. [3]
CDR Zhelyazko Nikolov, Assistant Professor Ph.D. [4]

1. Nikola Vaptsarov Naval Academy, Varna, Bulgaria, bobmednikarov@abv.bg
2. Nikola Vaptsarov Naval Academy, kalinov.ks@gmail.com
3. Nikola Vaptsarov Naval Academy, n.dimitrov@nvna.eu
4. Nikola Vaptsarov Naval Academy, zhelyazko_nikolov@abv.bg

Abstract. The research actions in the maritime domain today are very High-Tech oriented and require specialised research infrastructure. That is the reason for the necessity to invest in such a research infrastructure in order to keep the cutting edge level of maritime research and innovation.

Because we cannot afford a big amount of money in our budget for acquiring an expensive maritime research infrastructure, the only way to succeed is to conduct project oriented research activities. Proceeding this way, we have to convincingly prove that the research infrastructure will be used on an effective manner to benefit best.

One of the possible ways to reach maximum use of such an expensive maritime research infrastructure is to use it not only for the research activities but for education and training as well. We are gathering experience in this area applying for financing the project "Centre of Competence for the Black Sea offshore support". It is dedicated to establishment of Centre of Competence in the area of ICT that has the capability to support scientific research in the maritime area and the offshore business developments. At the same time the sustainability of the infrastructure is increased by using it as a simulator in the E&T of personnel for the offshore and nautical industry.

This optimisation is possible because of the use of competence, knowledge and information by means of software and hardware products. The modelling of the processes allows us tosimulate the functions of the real infrastructure and to provide complex standardized realistic and real-time simulation environments for the maritime and offshore industry, used in nautical studies and training facilities.

ICT in the area of simulation is a basis for personnel training and scientific research following the integration of the scientific/educational organization and separate scientists/instructors. We think about three possible areas of application of this infrastructure: simulators; technology transfer; training.

We hope the problem with the sustainability of the research infrastructure we are facing is addressed and resolved best.

Keywords: modelling, simulation, research and training, sustainability, integration

1. Introduction

The Bulgarian high education is close connected to the research, development and innovations (R&D&I) activities due to many reasons.
The most important among them is that R&D&Ihelp the academic staff to keep the level of knowledge and competences up-to date. The development of research and innovations activities in the EU member states and the regions is one of the key tools for achieving the targets under Europe 2020. This is the solid base for reaching a sustainable economic development and social prosperity. As a national priority, as well, our country tries to stimulate R&D&I activities creating appropriate environment in the universities and scientific institutions. This is valid in the maritime area, too.

On the other hand maritime education and training has to follow the global tendencies in the maritime domain[6]:

– increasing role of the automation of the processes and subsequent tendency for professionalization of the activities
– multiagency environment for maritime activities
– enlargement of the maritime activities geographically
– establishment of a common maritime safety and security system

Following the trends in maritime education and R&D&I the developments in the area are logically connected with the complexity approach that allows double use of the capacity - scientific and educational.

2. Modern simulation systems for marine personnel training

The maritime education system in Bulgaria prepares personnel for two major areas – the marine industry and the navy. The users of such personnel demand higher and higher standards for their level of training. A way the maritime education system to respond to the latest requirements and to reflect better the global tendencies in the maritime domain is to facilitate conditions of training as close as possible to the real world. Thus, the acquisition of simulators adequate to the requirements is becoming an important issue for the modern maritime training. Notwithstanding its financial aspect, the solution to this issue is indirectly preconditioned by the development tendencies for the maritime platforms, and directly - by the closely related to that progress prospects for the simulation systems.

2.1 Maritime simulation systems at Nikola Vaptsarov Naval Academy, Varna

One of the most important elements of the training equipment are simulators that allow to conduct training in conditions close to reality. To provide the necessary practical skills of students and cadets from different specialties 11 simulator are used, the majority of which were delivered in the last 2-3 years.The Naval Academy, Varna has a number of trainers involved in teaching and training of maritime personnel. All laboratories are built to the highest standards of learning and using modern facilities and advanced technical realization of leading companies in their respective fields. All teachers are trained and certified by manufacturers.

Simulators take a serious place in the courses under STCW, by meeting all requirements of the International Maritime Organization.

The following simulators are available:

- "Ship bridge" - TRANSAS-NTPRO- 5000
- Complex navigation simulator "Ship bridge" - TRANSAS-NTPRO-3000
- Navigation simulator "Ship bridge" - TRANSAS - NTPRO -5000 + ECDIS
- Navigation simulator "TRANSAS-NTPRO-3000 for maneuvering and radarguidance
- Electronic navigation charts simulator - ECDIS
- Simulator "NORCONTOL"
- Simulator "ERS - 5000"
- Simulator 'GMDSS"
- Simulator “VTMIS”
- Simulator "Watch Naval Officer"
- Simulator "Watch Naval Engine Officer"
- Simulator of information systems for vessel traffic monitoring and managing

[6]Mednikarov B, Transforming Maritime Education:Local Decisions in Global Perspective, International Association of Maritime Universities AGA11, pp. 367-376 [8]

- Simulation complex Information system for monitoring and integrated control of the coastal zone.

A number of laboratories are involved in teaching and training of maritime personnel. Could be outlined:
- Laboratory for preventing and oil spills response
- Laboratory for analysis and efficiency improvement of ship propulsion complex "NAVYSIM BRIDGE"
- Academic Training Workshop
- High Voltage Ship Laboratory (over 1000 Volts)
- Laboratory for marine power systems and electric drives for ships

All laboratories are built to the highest standards of learning and using modern facilities and advanced technical realization of leading companies in their respective fields. All teachers are trained and certified by manufacturers.

Nevertheless, we have a long list of simulators we need on one hand to keep them up-to date and on the second hand – to increase the training capacity of the Academy in order to be adequate to the market situation. This requires allocation of investments, even bigger one that could not be available any time. So we have found an alternative decision for such cases.

2.2 Trends of the modern simulation systems for the maritime E&T

2.2.1. Accounting for the diminished significance of the human factor.

The expected ever-increasing automation of ship control and maritime related processes will diminish the impact of the human factor on the navigation bridge, in the central command post, on the offshore installations etc., and this will lead to the creation of simulation systems facilitating the practice of issues related to:
- work with multifunctional software-supported consoles
- monitoring and control of software and hardware for processing information obtained from various sources
- analysis of data from the on-board computers and the environment and decision-making.

2.2.2. High level of integration – integrating the navigation, communications, firefighting, power plant and other simulators.

This prospect will direct the development of simulation systems toward the creation of virtual ship/installation models to enable simultaneous and joint practice of trainees from different specialties.

2.2.3. Making the working conditions as realistic as possible.

Enabling the realistic recreation of a wide array of factors from the environment – visual picture, weather conditions, noise, ship motions, vibrations, as well as working under time pressure and at involuntary rate.

2.2.4. Modern simulation systems for the naval personnel E&T and research.

Naval simulators play an important part in the preparation of personnel for the Navy. Simultaneously, some of them permit all-level operational and tactical modelling, facilitating conditions for academic research and for studying different scenarios for different operations. Beside the prospects mentioned in the previous paragraph, the expected development of the existing simulators by enhancing their capabilities for modelling and simulation of planning and conducting combat action, as well as enhancing the modelling of different platforms, weapons systems control, using communications and information support systems, electronic warfare, etc.

2.2.5. Technology transfer as a result of the increased importance of the simulation systems in the maritime E&T.

An important way and mean to facilitate technology transfer through simulations is finding, acquisition and utilisation of modern simulation systems. The steady trends in this direction give reasons to conclude that technology transfer is becoming a significant prospect in the context of the subject of this paper. In today's world, the need of sharing knowledge, skills and technology, especially in the marine industry, is ever increasing. Expanding the sphere of possibilities in this aspect can be supported by the use of simulation systems.

3. Capacity building for research, development and innovations

The specific needs that Bulgaria experiences in this area fall into several groups:

3.1. At a national level: increasing investment in R&D&I with a focus on excellent science

3.1.1. Increasing investment in R&D&I and enhancing research excellence.

The statistical data shows[7,8] that in the past seven years, the R&D intensity in Bulgaria increased from 0.45% of the GDP in 2007 to 0.67% in 2013. However, the latter value is still significantly lower than the national target of 1.5% by 2020[9], as well as the current EU average value of 2.06%. The increase in the total intensity is exclusively due to increased R&D investment in the business sector (to 0.43%), while in the public sector there was a decrease - from 0.31 in 2007 to 0.24% in 2012 (the lowest value in the EU)[10]. The main factor for the increase in the total R&D investment was the increased share of foreign funding (both private and EU funding), which grew from 7% in 2007 to 44% in 2011.

These persistently low levels of R&D funding in the country generated an array of negative consequences:[3,11]

- obsolete research infrastructure
- low payment for researchers
- emigration of talented and highly-skilled young researchers (brain-drain)
- significantly reduced interest in a research career among young people, and
- continuously decreasing interest in the study of engineering and natural science subjects. The overall scientific performance in Bulgaria is relatively low, as reflected in various indicators.[3] For example, of particular concern are the declining share of scientific publications featured in the top 10 % most-cited scientific publications worldwide, which are only 3.2 % from all scientific publications for 2009 (the third lowest value in the EU) and the low and falling level of public expenditure on R&D financed by business enterprise (-4.4 % as % of GDP over period 2007-2012) [3].

The level of Bulgarian participation in EU Framework Programmes is also limited. Both the applicant success rate of 16.5% and the EC financial contribution success rate of 10.5% are much lower than the EU averages (21.9% and 19.7% respectively). On the composite indicator of research excellence, Bulgaria ranks 21st in the EU.[3]

To overcome these negative trends Bulgaria needs to increase significantly the funding in R&D activities, mobilizing both public and private investments, with a special focus on research excellence.

[7]Research and Innovation Performance in Bulgaria, Country Profile 2014 [10]

[8] Data from the National Institute of Statistics for 2013

[9]National Development Program: Bulgaria 2020, adopted with decision 1057/Council of Ministers, 20.12.2012, p. 250 [9].

[10] Innovation Union Competitiveness Report 2013 SWD, January 2014[5]

[11]Innovation Strategy for Smart Specialization, The Republic of Bulgaria, 2014-2020 (draft 17.11.2014)[4]

3.1.2. Market-oriented research to boost innovation capacity and competitiveness

Bulgaria is a modest innovator and remains the poorest performer in the EU-28,[12] due to structural underfunding, difficult procedures to access project funding, fragmented funding in different areas, poor connections between science, education and business, and lack of strategic focus of the interventions in this area.[3,6] It is important to note that the poor performance is grossly affected by the excessively low R&D expenditure in the public sector as % of GDP, by the weak innovation activities of SMEs and by the strong orientation of the Bulgarian research system towards the basic research[13].

There are certain strengths that could be used as the basis for a market-oriented reform:[6,14]
- good traditions in natural sciences
- preserved science schools and high publication rate in specific areas which are relevant to the emerging technologies (physics, chemistry, materials science, biochemistry and molecular biology, medicine, pharmaceutical and engineering sciences)
- cultural diversity coupled with a specific national identity
- pronounced orientation towards international collaboration of researchers
- positive public attitude towards education and science.

Modern and well-equipped research infrastructures are important elements of R&D&I eco-systems.[9] The analysis of the National Research Development Strategy 2020 identifies the following negative trends in the state of play of research infrastructure in Bulgaria:
- outdated facilities and inefficient use of the existing facilities
- lack of advanced approach to the administrative and financial management of the existing infrastructure in base organisations
- lack of professionally trained and qualified staff to operate the facilities and their users
- lack of coordination and complementarity of available modern facilities within a single organisation or in between different organisations
- lack of concentration of equipment and, in some cases, a highly personalised approach and duplication of equipment.

3.2. At a regional level: Improvement of the territorial and thematic distribution of research infrastructure, with a view to regional smart specialization

Bulgaria's research system remains highly concentrated in institutional and geographic terms.[9]The top five institutions, all of them being located in Sofia city region, produce about 75 % of the total publications.[9] The analysis of the current map of research organizations in Bulgaria reveals the following features:

The most active scientific organisations in attracting funding (86 % of the total R&D funding in Bulgaria) and in the implementation of national and international projects are those in Sofia-city region[15]. These organizations have diverse research profiles and are involved in active cooperation with local and international companies.
Relatively high research activity and a clear regional specialisation can be observed in the Plovdiv region. The economic profile of the country's second largest city – Plovdiv, is strongly food- and agriculture-oriented[16].

[12]Innovation Union Scoreboard 2014 [6]

[13]cf. Figures 1, 7 and 11 in the Innovation Union Scoreboard 2014[6]

[14]Input to Bulgaria's Research and Innovation Strategy for Smart Specialization, World Bank Report, 2013 [7].

[15]Including the institutes of the Bulgarian Academy of Sciences, Sofia University "St. Kliment Ohridski", Medical University of Sofia, Technical University of Sofia and some other universities.

[16]The most active players in the area are: Plovdiv University "Paisii Hilendarski", Medical University of Plovdiv and University for Food Technologies.

The third most developed region in terms of knowledge and entrepreneurial dynamics is Varna[17]. The region is further important for the development of alternative energy sources and the conservation of the natural resources of the Black Sea region.

In the remaining Bulgarian regions there is no clear specialisation of the scientific organisations and their cooperation with the business.

Regionally sited research infrastructure and universities are of particular importance given the potential socio-economic that they can produce[18]. Universities in particular are critical 'assets', mainly in less developed regions where private sector may be weak or relatively small, with low level of research and development activity[19].

3.3 Necessity at institutional level

As noted in the World Bank Report, countries like Bulgaria need a viable, internationally connected scientific system, in order to absorb and economically benefit from the knowledge generated worldwide.[9] Therefore, systemic interventions are needed to support the Bulgarian research organizations and schools of higher education in their international research cooperation. These interventions will find a good basis – almost 50 % of all published articles are produced in collaboration with researchers from other countries.[9] Bulgaria's main partners are from high-performance countries. The efforts in favour of the internationalisation of Bulgarian research should be driven by the objective of achieving results in the areas where impact could be potentially the greatest for Bulgarian economy[20].

Several types of current needs could be identified in this context:
- It is necessary to create and modernize unique research infrastructures which could be included as integral parts of the distributed European research infrastructures
- Bulgarian researchers and research organizations need better and more systematic support in their efforts to be fully integrated in the European Research Area, including the development of future and emerging technologies at European level, as well as the participation in EU research programs, European technology platforms, partnership projects and networks.
- Bulgarian researchers need free and convenient access to the international databases of scientific data and publications, as they could not be fully efficient in their research without such access.

3.4 Possible financing for research infrastructure improvement

However, the strengths must be streamlined to materialize the innovation potential of the Bulgarian research institutionsand to work on their adaptability and sustainability through greater focus on market signals and ways to attract private investors[21,22]. The Operational Program Science and Education for the Smart Growth (OP SESG) should play a crucial role in improving the level of R&D&I and in activating the innovation potential that Bulgaria could move up from 'modest' to the level of 'moderate' innovators. For this purpose, OP SESG will focus the R&D&I financial resources and innovations on the following priority areas:[9]
- Mechatronics and clean technologies

[17]The best performing actors in Varna are: Technical University of Varna, Medical University of Varna and Oceanology Institute of BAS, working in areas such as quality of life, health and environment.

[18]Commission publication 'Connecting Universities to regional growth – practical guide' Sept 2011. [1]

[19]Guide to strategies for S3 – May 2012.[3]

[20]Science and Education for Smart Growth, Operational programme 2014-2020, pp. 12-18 [11]

[21]Study of DG RTDExpert Group, October 2013, sections 4.3-4,4[12].

[22]ERAWATCH report 2012, p. 17.[2]

- Informatics and ICT
- Industry for healthy living and biotechnology, and
- New technologies in creative and recreational industries.

The expected financial intervention by OP SESG to support research infrastructure improvement is app. 13M Euro – 15M Euro per Centre of Competence (CoC). Thus supporting the market-oriented R&D activities and mainstreaming the financial interventions from OP SESG in the priority sectors aims to improve the competitiveness of Bulgarian research system and overall economy.
The modernisation of research infrastructures can have important positive effects in several aspects:
- improving the opportunities for cooperation between leading scientific organisations and the business
- much higher quality of staff training in modern technologies
- improving the opportunities for involvement of Bulgarian scientific teams in European networks for development of new technologies in key enabling areas, which have been identified as priorities for Bulgaria and for the entire European Union.

In this context, it is crucial that universities are not seen only as islands for academic and fundamental research but as potentially strong contributors to the local economy including employment and industry[10]. They should become key players of regional specialisation and build the capacity to cooperate with businesses in the priority areas identified.

The negative trends, mentioned above, underpin a number of important issues whose solution requires a systemic approach. First, it is necessary to prioritise infrastructure investments which contribute to specialisation in the priority areas. Second, it is necessary to set up a national system for the use of large research infrastructures, created with public funds – with publicly available map of the research equipment, clear rules of its use, broad access for public organisations and businesses, maximum efficiency, and a unified system for the distribution of public results. Third, it is necessary to support the leading regional universities and scientific centres to adapt to the new priorities - this will require a modernisation of their laboratories and research equipment to improve their capacity for research and to allow them to provide relevant, business oriented services.

4. Integration of the maritime research and training trough theCentre of competence concept

Nikola Vaptsarov Naval Academy (NVNA) decided to benefit from the OP SESG establishing Centre of Competence (CoC) for the offshore support at the Black Sea region. The subject was chosen after analysis of the level of the offshore explorations and further actions and existing centres on the topic worldwide.

According to the developed CoC concept paper the mission of the CoC will provide practice-oriented scientific and educational/training support to the development of the strategic area of the maritime offshore industry, subsea actions and related support and supply activities, the national policy for training of highly qualified personnel for the European maritime economics.

The functional areas for the scientific activities will be:
– Offshore and related support and supply activities
– Subsea actions and engineering support
– Support and supply fleet
– Oil spill management.

As the analysis reveals the need for creation and development of a leading research centre it has to be equipped with modern research infrastructure and equipment, able to conduct top-level research and innovations at European level, with focus on offshore actions support.

The research activities will be focused on the optimisation of the functional parameters and control of the offshore installations, support fleet and oil spill response. As general, the acquired machinery samples will be used to prepare software (simulations) models of different type of equipment, installations and sensor systems. These models will be tested in a virtual environment in order to find a way to provide:

- Optimisation of the functional parameters of the authentic complexes
- Creation of the optimised models of education/training
- Determine the opportunities for new technologies and sample installations implementation.

Important role of the CoC is the development and the test of virtual models and sensor systems used in the area of ocean engineering and in education/training the personnel for the offshore industry.

A unique nature of the approach is that the CoC is proposed to be as a network of collaborations and partnerships between the academic and non-academic, public and private sectors. This will keep the existing unique research and training specialization and expertise of the institutions as well as of individual researchers, and will create a synergy of efforts that will allow further improvement of the existing capacities and avoidance of resource duplication in reaching the goals. Inclusion of a business cluster in this network will bring a benefit in correct needs identification and issues addressing, as well as to achieve knowledge and technology transfer, market oriented research program in order to improve the competitiveness of Bulgarian research system and overall economy.

Table 1 Expected specific outcomes of the CoC

2 years	5 years	10 years
R&D infrastructure improvement; 5 doctoral researches in the area of offshore support launched	Completed 4 doctoral programs Cooperation and participation in international joint R&D teams	Completed 2 research project and generated 4+ Publications with impact factor
Generate 2 R&D activities on offshore industry request	Completed 2 R&D activities on industry request; stabile training environment	Conducted R&D on yearly industry request; Continuous training.
Accredited: - Master program - Doctoral program	Graduated masters and doctoral degree; Min 30% women involved;	Young specialists educated and trained in offshore area

The expected benefit of the CoC operation will be complex. Both sides – researchers and users (business) will directly benefit from the CoC initiatives, and indirect ones will be for the society and regional/national economy. The benefits will include:

- coordinated policy for scientific and innovation activities
- modern research and innovation infrastructure
- integrated institutional research environment
- excellent training opportunities
- favorable age profile
- interaction between research/training institutions and companies.

The general outcomes include:

- networking collaboration and partnership between the academic and non-academic public and private sectors in the area of offshore support
- successful knowledge and technology transfer
- strengthening the synergy of the scientific organizations' efforts and key economic entities leading to overall economic development of the region
- Preparation of next generation researchers and training needed for the offshore industry.

The specific outcomes refer to the objectives and future expectations are defined in table №1.

5. Conclusion

The upgrade/modernization of the scientific infrastructure of the academies and research institutions is needed and planned based on the conducted analysis of the current status and the level of ambition at national level. The financing will be used for the establishment of modern research center (CoC).

The developed concept paper for CoCfor the Black Sea offshore supportstresses on the need to acquire the necessary scientific infrastructure in the area of maritime and offshore actions and organizational establishment. At the same time this infrastructure has to be maintained and upgrade during the life cycle. Not to forget that the modern technologies are rapidly evolving and therefore grow old very quickly. Using the software simulations (as part of the scientific infrastructure) for the training purpose out of the research time (that expect to be significantly lower) will increase the sustainability of the research infrastructure and will guarantee incomes that may be used for maintenance and upgrade during the life cycle. Thus integration of research and training on common infrastructure will increase its sustainability and effectiveness compared with the separate conduction.

The opportunity to acquire research infrastructure could be motivated and supported better by involving it in the training and qualification activities. This way the integrity of the scientific infrastructure will be the main guaranty for itssustainability, i.e. the integration of the research with the training and qualification activities.

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