



Developing the Croatian Underwater Robotics Research Potential

PROJECT FINAL REPORT

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Final Report of the FP7 CURE project

4.1. FINAL PUBLISHABLE SUMMARY REPORT

4.1.1 An executive summary

The project „Developing Croatian Underwater Robotics Research Potential“ - CURE (<http://cure.fer.hr>) significantly improved Croatian research potential in underwater systems and technologies and enabled intensification of dissemination of UNIZG-FER-LABUST (University of Zagreb-Faculty of Electrical Engineering and Computing-Laboratory for Underwater Systems and Technologies) research results and capabilities that can accommodate needs of Croatia and the whole West Balkan region related to the exploration of underwater systems and technologies. The CURE project enabled intensified proliferation of underwater robotics knowledge in Croatia. The transfer of knowledge (ToK) undertaken during the duration of the project showed intense activity within the scope of the project providing both LABUST researchers and a diverse user community an opportunity to have deep insight into the corresponding technology. Besides revealing a huge potential of underwater robotics, the CURE project also provided a big momentum for scientific and commercial applications in the region. All project tasks were realized according to plan and the project fulfilled all stated goals and even exceeded some of them. The project significantly reinforced UNIZG-FER-LABUST S&T potential, mobilised its human and material resources, developed partnership with EU research entities and established contacts for possible future cooperation with research entities from all over the World (USA, Japan, Australia, Brazil). The CURE project facilitated dissemination and promotion of our research results and enabled LABUST to raise awareness among various stakeholders in the field of sub-sea domain, about use and capabilities of the underwater systems and technologies for their benefit. Interdisciplinarity and inter-sectoriality that is today a necessity in the area of underwater systems and technology development characterized efforts in the CURE project. A lot of interest, coming both from Croatian institutions and CURE cooperating institutions, is expressed for joint experimentation, missions at sea and transfer of knowledge (ToK). UNIZG-FER-LABUST activities will be also in the future focused toward those that can boost regional development of underwater capabilities. All project goals were fulfilled for the benefit of the UNIZG-FER-LABUST but also Croatia, the WB region and also EU.

4.1.2 A summary description of project context and objectives

The CURE project addressed all of the topics of the FP7-REGPOT-2008-1 call of the FP7 Capacities program:

1. Reinforcement of S&T potential,
2. Developing strategic partnerships with well established research groups,
3. Supporting and mobilizing the human and material resources,
4. Facilitating communication between the centres having similar scientific interests,

5. Disseminating scientific information and research results,
6. Improving the responses to socio-economic needs.

CURE activities were focused on the following objectives (Annex I):

1. (WP1 and WP2) Upgrading the existing research infrastructure at UNIZG-FER-LABUST by purchasing new equipment (WP1), employing 5 researchers, including 1 expert from abroad (WP2).
2. (WP3) Mobilization of human resources by transfer of knowledge between LABUST researchers, collaborating experts and other experts from the field. For this purpose, each year one field-training and one spring workshop were organized with different goals for each of these. Top scientists in the field were invited to spring workshops and field-trainings. Secondments and joint missions at sea were realized for better transfer of knowledge and research purpose.
3. (WP4) Promotion of the CURE project results were realized through various means such as:
 - the CURE web site (<http://cure.fer.hr>),
 - presentation of research results at
 - conferences with peer review,
 - special sessions with peer review,
 - journals with peer review,
 - round tables with specific topics,
 - workshops (IPSIT2010, IPSIT2011, IPSIT2012)
 - field-trainings (BtS2009, BtS2010, BtS2011)
 - press/media coverage of CURE activities,
 - promotion of LABUST and its achievements at exhibition (ASDA2011)
 - missions at sea for different stakeholders,
 - a data base was designed and made public at the CURE web site, that provides information about type and number of underwater or surface robotic vehicles in the region, of the scope and interest of R&D groups in the region, of those SMEs that are active in underwater robotics or are involved in various marine applications, of end-users, industrial partners and governmental bodies.
4. (WP5) Project management was active from day one and remained so till the end of the CURE project. The management activities accomplished the fulfillment of all planned goals.

All tasks were realized according to plan and the project fulfilled all stated goals and even exceeded some of them. The CURE project improved **Croatian Underwater Robotics Research Potential** for the benefit of EU, regional and local community. The project significantly reinforced UNIZG-FER S&T potential, mobilised its human and material resources, developed partnership with EU research entities and established contacts for possible future cooperation with research entities from all over the World (USA, Japan, Australia, Brazil). The CURE project facilitated dissemination and promotion of our research results and enabled LABUST to raise awareness among various stakeholders in the field of sub-sea domain, about use and capabilities of the underwater systems and technologies for their benefit. Interdisciplinarity and inter-sectoriality that is today a necessity in the area of underwater systems and technology

development characterized our efforts in the CURE project. A dialog between potential end-users from different disciplines and R&D team from the UNIZG-FER Laboratory for Underwater Systems and Technologies (LABUST) intensified, resulting in closer cooperation in various activities such as project proposals, joint mission planning, realizing joint missions at sea, preparation of future activities that will enable Croatia to fulfil legal obligations (related to sub-sea areas and sustainable development of these resources) that will be enforced with accession of Croatia to EU in 2013. Here we mention only few such as: preserving the underwater habitats, monitor biological/ecological changes in sub-sea and coastal areas (Natura2000), preserving and keeping our water resources unpolluted, protecting cultural heritage (underwater archaeology, civil constructions etc.) and maritime security responsibilities.

4.1.3 A description of the main S&T results/foregrounds

Our research was application oriented and was mainly related to the needs of end-users. We published around 13 publications per year and this number clearly shows that we were productive concerning the fact that the CURE is SA type of project. New developments were initiated such as use of cloud computing (consumer programming) for the mission planning and report generation after the mission. This is a new development that nobody is using at present in the domain of underwater robotics. Cloud computing (consumer programming) is a hot topic in some other areas of research and we will soon have some very interesting R&D results that will be published in journals and at conferences. Our approach will change the way how the mission at sea will be planned, executed and finally reported in the future. We were also investigating the use of human hearing capabilities that could ease ROV operator work. It is interesting to note here that human hearing capabilities were not explored before for guidance purposes despite the well known fact that ROV operators are highly burdened with a lot of visual information in their work. Our present results are very promising and soon we will have experiments at sea that will give us more information of quality and ability of our R&D in this domain. Another development that originated in our laboratory and that was described in the Ph.D. dissertation by Assist.prof. Nikola Mišković was a simple identification method based upon self-oscillations that enabled identification of parameters for marine unmanned vehicles (underwater and surface) of non-linear mathematical model of the vehicle. This method is simple, affordable, easy to perform and fast. With this method it is easy to identify parameters of a mathematical model of a vehicle when sensor suite of the vehicle change, which often happens during missions at sea. This method was detected by our colleagues from NATO Undersea Research Centre and they offer us a cooperation on their project dealing with mine-countermeasure with autonomous marine vehicles. Our laboratory became responsible for the underwater part of their system, and results of this project are already very promising. Our method became de-facto standard method of identification at National Research Council-Institute of intelligent systems for automation (CNR-ISSIA), Genova, Italy where it was applied to their marine vehicles with great success. Some other research groups are experimenting with our method (University of Limerick, Department of Electronic and Computer Engineering, Limerick, Ireland; Istituto

Superior Tecnico, Institute for Systems and Robotics, Dynamical Systems & Ocean Robotics Lab, Lisbon, Portugal) and their responses are also very positive. Our expertise in guidance and control of AUVs based only on acoustic feedback is a new development that originated in our laboratory and that was implemented on NATO-NURC project. This is also original R&D and innovative development of how guidance of one autonomous underwater vehicle can be performed from another autonomous vehicle (surface or underwater) without the help of an operator. We expect one Ph.D. based on R&D in this domain to be finished in near future. Another interesting R&D that was published in one Ph.D. (Matko Barišić, Ph.D.) dealt with use of virtual potential method for mission planning of formation of AUVs for the purpose of cooperative missions, evading moving and fixed obstacles. This research successfully resolved the problem of cooperative mission planning in areas with low information exchange capabilities. This is something that characterizes underwater areas and presents the main obstacle for reliable and well behaved cooperative mission executions.

4.1.4 The potential impact

Expected impacts from the work programme were:

- Upgrading the RTD capacity and capability (human potential: number of new researchers and training of research staff, improvement of research management, scientific equipment) as well as the quality of research carried out by the selected research entities;
 - Better integration of the selected research entities in the European Research Area as a whole (partnership, including twinning with research groups elsewhere in Europe);
 - Contribution to regional capacity building;
- Improvement of the potential of the selected research entities to participate in FP7 projects

CURE did have an impact in the whole region in the domain of underwater robotics (underwater systems and technologies) R&D and clustering. LABUST offered services for all interested parties (R&D groups, end-user community, industrial sectors (SMEs), governmental bodies, general public).

- Those involved in R&D have the possibility to search for partners, exchange information about their own and possible joint R&D projects, exchange information about European RTD projects in Embedded Systems & Control, Robotics, Marine security, etc.
- End-user community had the possibility to use LABUST expertise for their applications, and to use our developed solutions there.
- SMEs had the possibility to embark on new production/services for the sub-sea community with the LABUST help
- Governmental bodies had the possibility to use our expertise for their needs in fulfilling legal obligations related to various domains (nature protection, maritime security, cultural protection, ...) for the sub-sea domain in Croatia
- Students had the opportunity to be involved in some very interesting and far reaching activities with our laboratory. Some of them embark on R&D in this fast changing research area

- General public was well informed about our role and activities due to frequent coverage by press/media. Even President of the Republic of Croatia wanted to be better informed about our achievements and we were invited in his office to present our work.

CURE thus increased awareness about LABUST R&D achievements and universities, research institutes and industry (large and SMEs) in the sub-sea domain are now well informed about our competence and work. For instance UNIZG-FER-LABUST signed the cooperation agreement with the University of Zadar. UNIZG-FER also signed the cooperation agreement with our Ministry of Defense of Republic of Croatia. Also, UNIZG-FER-LABUST signed the agreement of cooperation with Aurora Trust (Florida,USA), and with NATO-NURC (La Spezia, Italy). The LABUST knowledge base was build upon the existing knowledge and competence of EU and local collaborators involved in this project as well as the knowledge and expertise of other experts from EU collaborating institutions, scientific and industrial bodies, chambers of commerce, business or governmental agencies. Services that were established included: Web sites, workshops, round tables, field-trainings, promotion materials for media/press, exchange of knowledge, secondments. The data base that was established on the CURE Web site and that will remain available after the end of the CURE project is very useful to policy makers, R&D partners, industrial partners and various EU bodies.

The project fostered networking and increased awareness of R&D players about their own opportunities especially to bring them together to join their efforts in research and development. Many FP7 proposals were initiated during our workshops or field-trainings at Murter. Our competence became more visible to others for the benefit of all.

CURE was very successful in exploiting the potential for co-operation that exists among research groups in EU. We were invited to join around 10 FP7 project proposals of which one is already contracted (FP7 CART project) and one is in negotiation phase and will start from 2013 (FP7 EUROFLEETS2). Our knowledge about underwater systems and technologies was collected, distributed and publicized.

CURE impact was possible due to the following:

- in WB countries this kind of endeavor is in its infancy;
- our collaborators were carefully chosen based upon their expertise and experience, and good background in R&D;
- our support actions (workshops, field-trainings, round tables, ..) were explored in the CURE project in such a way that awareness of local researchers, engineers, experts from various local scientific and industrial bodies, chambers of commerce, business and governmental agencies (policy makers) and general public was significantly raised;
- our R&D in underwater systems and technologies is most advanced and other research groups are accepting our methods as valid and helpful in their R&D;
- our EU collaborators and UNIZG-FER-LABUST researchers have good international recognition in research and education and this was of great help in facilitating initiatives for international co-operation for all those capable and interested to be involved in EU projects or partner search;

- experience gained through this project was transferred to comprehensive documentation with know-how for the future transfer of the pilot to other regions and R&D areas.

The impact of the CURE project was high in every aspect especially socio-economic one. Namely, we are now consulted and engaged in various projects/missions for state agencies such as State institute for nature protection, National park Kornati, Croatian Conservation institute, Croatian Navy and some others. Due to the fact that this kind of endeavour was the pilot one for this area of Europe, the experience and know-how that came as a consequence was very useful also to others who are planning to embark on a similar endeavour. We established good relations with the Institute of Marine Biology (Kotor, Montenegro) and also Regional Center for Divers Training and Underwater Demining (Bijela, Montenegro). Also, contacts with Harpha Sea Ltd (Koper, Slovenia) were established and plans for FP7 project proposals are at the moment underway with them. All our dissemination activities are well presented at the CURE Web site <http://cure.fer.hr> and also at the "Breaking the surface" (BtS) Web sites: <http://bts.fer.hr/Bts2009/>; <http://bts.fer.hr/Bts2010/> and <http://bts.fer.hr/Bts2011/> where a lot of information can be found. On the CURE Web site some of TV coverage and press articles are given. We are happy that our original idea with the BtS field trainings were very well accepted and is now followed as a model for some other workshops such as for instance in FP7 TRIDENT workshop that is planned for October 2012. Monterey Bay Aquarium Research Institute (Monterey, California, USA) also found our concept interesting and will follow it in their future planned workshops. Office of Naval Research Global will finance BtS for 2012, 2013 and 2014, and this fact speaks a lot for itself.

4.1.5 The address of the project public web site

Photographs, illustration and promotion of our work in the CURE project (video clips, articles in newspapers, lectures, IPSIT and BtS programmes, publications, etc...), as well as all relevant information can be found at the following project web site: <http://cure.fer.hr>. Also, the web site of the Laboratory for Underwater Systems and Technologies <http://www.fer.unizg.hr/zari/labust/> will have all the information about our activities beyond the CURE project.

Zagreb, 31.05.2012.

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