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Summary:

This deliverable contains whitepaper on preparation of technology platforms and evaluation of commercial potential in Croatia for all four strategic research domains (SRDs) of the ACROSS Centre of Research Excellence: SRD1 - Cooperative Cognitive and Robotic Systems, SRD2 - Cooperative Networked Embedded Systems, SRD3 - Cooperative Renewable Energy Systems, SRD4 - Cooperative Control Methods. This document presents ACROSS activities in context of actual economic situation in Croatia and alignment of future objectives within EU strategic framework.

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Executive Summary

In last few years Croatian economy has entered period of recession. Industrial activity has been decreasing as well as export of industrial products. R&D&I activities in private sector are sporadic and national public funding of R&D&I has been significantly reduced. First national call for research centres of excellence has been announced in 2013.

At the same time, since Croatia has become a member of the EU, a lot of efforts have been done in preparing strategic documents and planning for usage of EU cohesion funds. Some examples are national strategy for education and research, national innovation strategy, national industrial strategy and strategy for smart specialisation. A lot of academics, including ACROSS researchers, are involved in the process of creation of the strategic documents.

ACROSS Centre of Research Excellence has four Strategic Research Domains: Cooperative Cognitive and Robotic Systems, Cooperative Networked Embedded Systems, Cooperative Renewable Energy Systems and Cooperative Control Methods. This White Paper presents framework for preparation of technology platforms in these Strategic Research Domains in context of the above mentioned environment. We also provide a report on assessment of commercial potential in cooperative technologies. Finally, we propose a long term R&D&I platform for sustainability of the ACROSS Centre.

This document is a living document that will be revised and updated throughout the lifespan of the project, to take into account new information from the Croatian companies and also will be adjusted to the Croatian technology platform(s) development within activities of Croatian Competitiveness Cluster of ICT industry and other relevant sectors (see chapter 3).

1 Introduction

1.1 ACROSS – Centre of Research Excellence for Advanced Cooperative Systems

1.1.1 Concept and objectives

The ACROSS[1] Centre of Research Excellence for Advanced Cooperative Systems aims to unlock and strengthen research potential of the Faculty of Electrical Engineering and Computing at the University of Zagreb (UNIZG-FER, www.fer.unizg.hr) for the benefit of the national, as well as the regional and EU community. The Centre reinforces UNIZG-FER S&T potential, mobilises its human and material resources, develops partnership with outstanding EU research entities and local industry, disseminates and promotes research results and raises awareness among various stakeholders in the area of cooperative systems of different types for emerging applications.

Cooperative systems are systems that consist of individual entities that jointly strive to reach a common goal, which involves sensing or controlling of devices, and are dynamically and loosely federated for cooperation. Cooperative systems extend the capabilities of single systems to carry out tasks requiring cooperative skills. Possible applications of advanced cooperative systems are numerous: advanced flexible manufacturing, renewable and sustainable energy, home and office automation, transport, logistics, environmental monitoring, healthcare, security and surveillance, human augmentation etc.

The ultimate goal of the ACROSS Centre is to be at the forefront of research and development of novel methodologies and advanced engineering approaches for cooperative systems. The research activities of the Centre focus on four major Strategic Research Domains (SRDs):

- SRD1 - Cooperative Cognitive and Robotic Systems,
- SRD2 - Cooperative Networked Embedded Systems,
- SRD3 - Cooperative Renewable Energy Systems,
- SRD4 - Cooperative Control Methods.

The first three strategic research domains are application-oriented and are among major pillars of the UNIZG-FER's R&D strategy[2], as their potential for national economic and societal development has been recognised. The research in the fourth strategic research domain is of paramount importance for advanced cooperative systems in general, as a fundamental enabling technology.

The Centre of Research Excellence is created by unlocking and strengthening UNIZG-FER's existing research potential in all four research domains targeted by the ACROSS project in order to successfully participate in research activities at the EU level and to significantly contribute to Croatian economic and social sustainable development. The Centre acts as a catalyst in amalgamating research capacities of the UNIZG-FER's research groups involved in the project and as a point of contact between academia and industry, providing an infrastructure for research exchange in the area of cooperative systems.

Development of advanced cooperative systems, which optimally use capabilities of cooperating entities, requires a coordinated, multi-disciplinary research in the fields of control

[1] http://across.fer.unizg.hr/
[2] http://www.fer.unizg.hr/en

engineering, computer science, communications, electronics, energy consumption and information technology. The ACROSS Centre consists of fourteen (14) research groups from seven (7) UNIZG-FER Departments with required multi-disciplinary R&D expertises. The ACROSS Centre is organised in four research teams, one for each SRD. These SRD teams have been formed according to the complementary expertise of research groups. The SRD1 Team consists of five research groups from four Departments. The SRD2 Team consists of four research groups from three Departments. The SRD3 Team consists of four research groups from three Departments. The SRD4 Team consists of five research groups from two Departments.

Twenty seven key experts and sixty PhD students and Post-docs in the ACROSS Centre represent about 20% of the total UNIZG-FER research staff. They conduct the project in tight collaboration with 16 leading EU experts from 10 EU Member States and Switzerland and 3 experts from Croatian partner companies. The EU experts have been selected based on their complementary skills and internationally recognised research achievements in the ACROSS' SRDs and Croatian experts based on their competences in product design and development in respective SRDs.

The ACROSS Centre fosters support actions for reinforcing research infrastructure and human resources and enables future research in four Strategic Research Domains (SRDs) at a much higher level. The RTD objectives are better served by a synchronised and integrated execution of research activities in all four SRDs, since each SRD can benefit from research results obtained in other SRDs. ACROSS Centre helps reorganizing and better integrating research activities of the involved UNIZG-FER research groups. In the end this “pays dividends” to the UNIZG-FER, local community, Croatia, and the EU.

On a first glance, the three ACROSS’ application-oriented research domains are quite diverse. However, there are a lot of interrelated and complementary research topics. The cooperative control is the major topic that is of common interest for cognitive systems and robotics, networked embedded systems and renewable energy systems. We focus our research on the development of a “general” cooperative control concept based on merging the techniques from the computer science field of multi-agent systems and techniques from the control-engineering field of model predictive control, intelligent control, discrete-event control, model reduction and state estimation. Besides the cooperative control methods, of common interests are also wire(less) sensor/actuator embedded networks as hardware enabling technology for cooperation and communication and signal and information processing and fusion methods as “soft” enabling technologies for cooperation.

The following main Sub-Objectives (SOs) are executed in the ACROSS Centre:

SO1. Increase Research Management Potential

SO2. Develop Strategic Partnerships with Outstanding EU Research Entities in EU and leading Croatian industrial partners

SO3. Increase Human Potential

SO4. Increase Technology Potential

SO5. Increase Scientific Visibility and International Reputation

SO6. Improve responses to socio-economic needs in Croatia

SO7. Earn a certified recognition “EU Centre of Research Excellence”

Work package 6 (WP6) - Dissemination, Regional Development and Impact Assessment - work effort includes facilitation of a regional multi-valued network of research centres, entrepreneurs, regional government, and investors for integrated actions in creating research driven clusters.

1.1.2 Impact

Croatia is a small country with the gross domestic product (GDP) per capita of about 63% of the average EU GDP and with only 0.7 – 0.8% of GDP[3] being invested in science, research and technological development. It is, therefore, very difficult for any Croatian research entity to significantly increase the level of its research activities and aim to achieve world-class research results without the EU funding. That is why the UNIZG-FER, as the leading Croatian R&D institution in the fields of electrical engineering and ICT, proposed the ACROSS project and established the ACROSS Centre of Research Excellence for Advanced Cooperative Systems with its four strategic research domains.

The UNIZG-FER research groups involved in ACROSS have participated, mostly individually, in a number of international and national projects and initiatives in the strategic research domains addressed by ACROSS. The ACROSS' coherent Action Plan significantly boosted the research capacity of the UNIZG-FER in cooperative systems related to robotics, networked embedded systems and renewable energy systems.

ACROSS has strong impact on Croatian economic and social development by offering information and services based on UNIZG-FER's upgraded RTD capacity and capability to all interested stakeholders (R&D groups, end-user community, large industry and SMEs, governmental bodies) and 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 ACROSS SRDs.
- End-user community have the possibility to use UNIZG-FER expertise and developed solutions for their applications.
- Large industrial companies and SMEs, particularly ACROSS industrial and SME partners (DOK-ING, ENT and KON-IET), and spin-off companies have the possibility to embark on new production/services with the help of UNIZG-FER.
- Governmental bodies have the possibility to use our expertise to improve legislative solutions and to prepare for the Technology Platform for related domains in Croatia.
- With the help of UNIZG-FER contacts, students have the possibility to embark on R&D in these fast changing research areas soon after receiving their M.S. degree, as well as to start their own business in these domains.
- General public is informed about the R&D going on at UNIZG-FER and other issues related to ACROSS SRDs from a competent source.

The increase of the ACROSS impacts by the dissemination and exploitation measures are:

- Increased awareness of players (particularly in Croatia) about the existing opportunities and open channels for national and international cooperation in terms of R&D proposals, scientific cooperation or business contacts based on technological innovation.
- Increased awareness for need of more investments in ACROSS related research domains in Croatia.
- Increased awareness of general population about new R&D activities and services that can be explored in ACROSS related domains in Croatia and elsewhere.
- Increased exchange of experience among end-users, manufactures, R&D players, policy makers and other stakeholders for the benefit of all.

[3] http://epp.eurostat.ec.europa.eu/

- Increased attraction of students/researchers for careers development in ACROSS related research domains.
- Increased awareness of possibilities for future employment in spin-offs, SMEs and industry which are active in new developments, manufacturing and/or services in ACROSS related domains.

1.2 Technology platforms - research and development agenda

The term 'technology platform' is used in different ways to describe priority areas and a mechanism to improve the effectiveness of research investment and its strategic direction. The final goal of a technology platform is to underpin economic and social progress and competitiveness[4].

1.2.1 European technology platforms

In March 2003, the European Council called for strengthening of the European research and innovation area by '… creating European technology platforms (ETPs) bringing together technological know-how, industry, regulators and financial institutions to develop a strategic agenda for leading technologies'. European technology platforms were set up as industry-led stakeholder forums with the aim of defining medium to long-term research and technological objectives and developing roadmaps to achieve them. Their aim was to contribute to increasing synergies between different research actors, ultimately enhancing European competitiveness.

The European Commission has supported the development of European technology platforms and has carried out a facilitation role. European technology platforms are bottom-up, industry-led initiatives; the Commission participates in their events as an observer and is committed to a structured dialogue on research priorities. All European technology platforms have brought together stakeholders, reached consensus on a common vision and established (and in some cases already revised) a strategic research agenda. Some of them have also developed an implementation plan detailing the actions required to implement the strategic research agenda.

The European platform concept was devised to contribute to competitiveness (as part of the European Research Area Lisbon Agenda), to boost research performance and to concentrate efforts and address fragmentation. Characteristics of such platforms should include high research intensity, major technological advances in the medium to long-term, with clearly defined European added value. The platforms should involve a wide stakeholder base (including industry, public authorities, the research community, regulators, civil society and consumers), mobilization of public and private funding as well as the Community Framework Programmes, Structural Funds, national, regional and private research funding, European Investment Bank, EUREKA, etc.[5]

European technology platforms are defined in the following areas[6]: energy, ICT, bio-based economy, production and processes, and transport. Some European technology platforms of interest for ACROSS Centre of Research Excellence are: ICT Technology platforms – ARTEMIS, EUROP, EPoSS, NEM; Energy Technology platforms – SmartGrids, TPWind, Photovoltaics, RHC.

[4] TECHNOLOGY PLATFORMS- from Definition to Implementation of a Common Research Agenda, Report compiled by a Commission Inter-Service Group on Technology Platforms, Directorate-General for Research, 2004, ftp://ftp.cordis.europa.eu/pub/technology-platforms/docs/tp_report_defweb_en.pdf

[5] Irish Council for Science, Technology & Innovation - Statement Strategic Technology Platforms, 2005 http://www.sciencecouncil.ie/media/icsti050315b_strategic_technology_platforms.pdf

[6] http://cordis.europa.eu/technology-platforms

It is important to carefully monitor developments of an ETP in order to maintain synchronization of the national technology platforms and ability of a country to influence designation of ETPs and, consequently, allocation of R&D&I funding at the EU level. Investment needs to be strategically focused on those areas of greatest relevance to state's enterprise and to its strengths in natural resources[7].

Strategy for European Technology Platforms: ETP 2020, from July 2013, seeks to maximise the impact of the ETPs. ETPs will be a key element in the European innovation ecosystem and will help turn Europe into an Innovation Union. ETPs have role as part of the external advice and societal engagement needed to implement Horizon 2020.

1.2.2 Croatian technology platforms

Croatia does not yet have long term research agendas defined by industry, research community and/or government. Recently established Croatian Competitiveness Cluster of ICT sector has been in process of preparation of Strategic Directions of the ICT sector (by the end of November 2013). It is expected that the process of establishment of national technology platforms will start in early 2014. This is for the first time that national technology platforms will be established in Croatia. ACROSS Centre will actively contribute to the ICT platform development (Prof. Vedran Bilas, ACROSS WP6 Leader, is a member of the ICT Cluster Management Board) and is actively involved in the establishment of the "Croatian Smart Grid Technology Platform". In cooperation with the Ministry of Economy of the Republic of Croatia, ACROSS organized a "Workshop for Preparation of Croatian Technology Platform for Cooperative Renewable Energy Systems and Smart Grids" held in Zagreb on July 2, 2013 (more than 130 participants). It would be of great importance that Croatian Technology Platforms will be coherent and synchronized with the latest ETPs landscape to enable integration of Croatian R&D institutions as well as SMEs into Horizon 2020 and other EU funding frameworks and boost innovation in Croatia, which is among the worst ones in EU, Fig. 1.

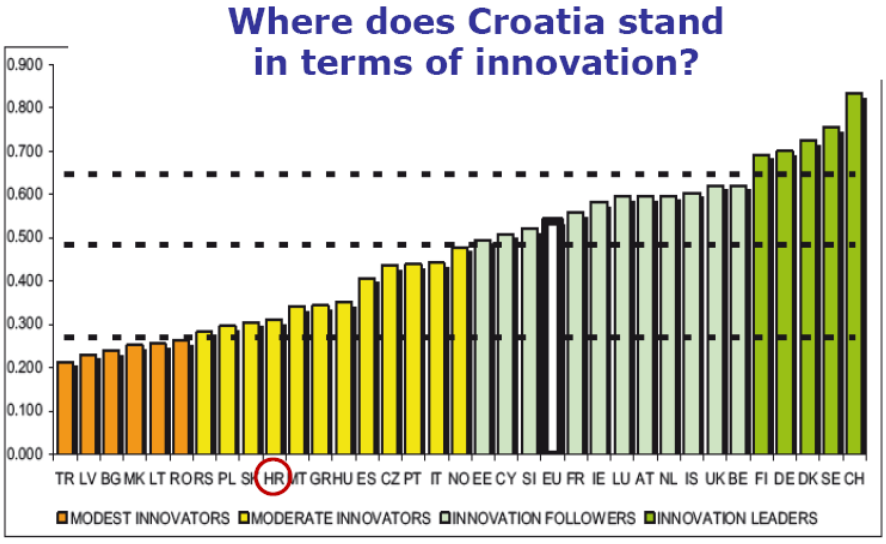


Fig. 1 Innovation performance of European countries[8].

[7] Commission Staff Working Document, Strategy for European Technology Platforms: ETP 2020, 2013, ftp://ftp.cordis.europa.eu/pub/etp/docs/swd-2013-strategy-etp-2020_en.pdf

[8] Research and innovation strategies for smart specialization (RIS³) Katja Reppel, Deputy Head of Unit, CC Smart and Sustainable Growth, DG Regional and Urban Policy, http://s3platform.jrc.ec.europa.eu/documents/10157/62973/0207%20Palma%20peer-review%20RIS3%20state%20of%20play%20KR.pdf

2 Assessment of R&D&I and commercial potential in Croatia

2.1 Data collection

In order to assess the R&D&I capabilities as well as market potential of cooperative systems and technologies in Croatia, information was collected on a selected number of Croatian companies and R&D groups. Initial selection of contact entities was performed by the members of ACROSS Centre team (for each SRD separately) based on formal or informal contacts with industry and researchers in the field. Contact forms with a request for basic information on business and R&D activities were sent to the selected entities in order to create a database of the corresponding companies[9] and R&D group profiles[10]. Since the initial response was very low, the contacting process was repeated on several occasions[11].

The end results are shown in Fig 2. A total of 108 companies and 25 R&D groups were contacted and entity profile information was received from 25 companies and 2 R&D groups.

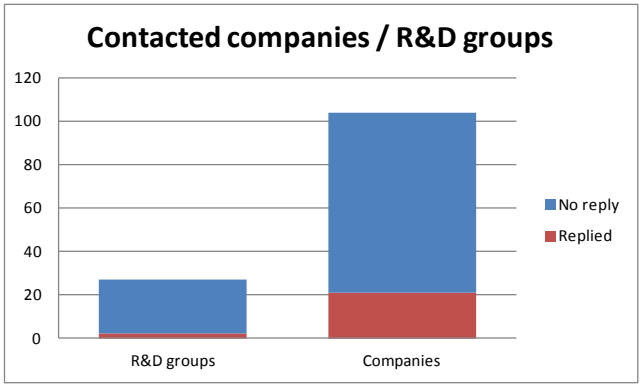


Fig. 2 Data collection from companies and R&D groups.

2.2 Analysis of technology end-users and market potential in Croatia and comparison to the EU

2.2.1 Croatian companies and cooperative technology end-users

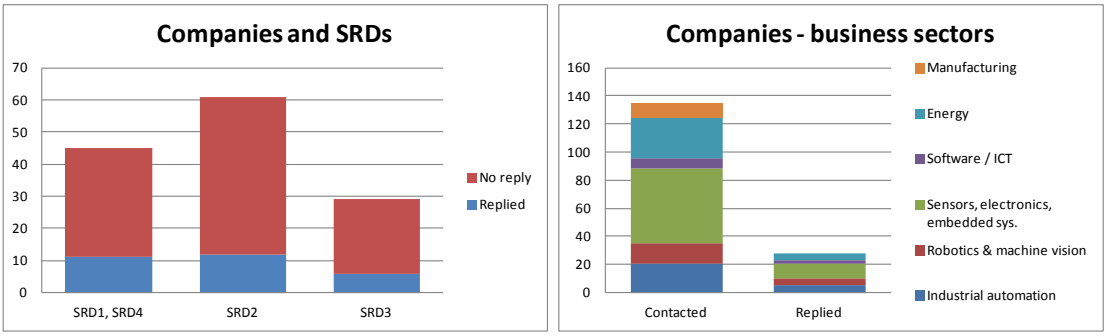
During the initial selection of companies within the cooperative systems field, a rough classification into three distinct groups was performed, based on their business portfolio. The group classification basically corresponds to SRDs, with the exception of SRD1 and SRD4 which were joined into a single group due to a large overlap of companies engaged in both control methods and cognitive and robotic systems, Fig 3a.

Based on initial estimate, as well as on gathered data, companies were further classified into six dominant business sectors, Fig. 3b:

- Industrial automation
- Robotics and machine vision
- Sensors / electronics / embedded systems
- Software / ICT

[9] ACROSS database, http://across.fer.hr/across/intranet/database/companies
[10] ACROSS database, http://across.fer.hr/across/intranet/database/rd_groups
[11] Same companies were contacted by many public institutions for various surveys in a very short period of time and in the middle of the economic crises, and that is the reason for low response rate.

- Energy
- Manufacturing



a) b)

Fig. 3 Data collection from companies: a) SRDs, and b) business sector distribution.

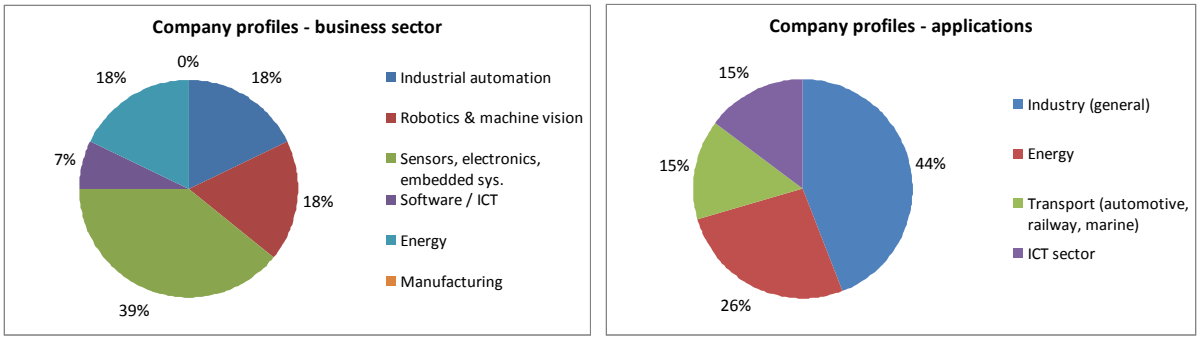
The relative shares of each business sector within the group of 25 selected companies are given in Fig. 4a. An additional classification of companies was made based on their dominant application market, i.e. key customers. In our analysis, we consider companies as technology providers and their customers as potential end-users of cooperative systems technology.

For the analyzed case, there are four dominant application areas:

- Manufacturing industry (in general)
- Energy
- Transport (automotive, railway, marine)
- ICT sector

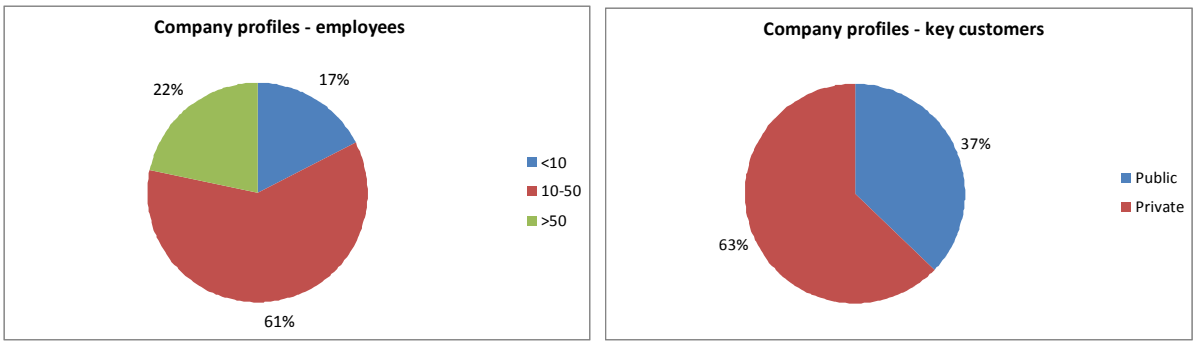
Fig. 4b shows the relative shares of each application market within the same group of companies.

Profiles of the analyzed companies with respect to their size (number of employees), structure of key customers and export shares are given in Fig. 5.a, Fig 5.b and Fig 6, respectively. From the given company profiles, it is evident that the majority of companies are small enterprises (<50 employees) that are strongly oriented towards customers in the private sector, mainly on domestic market.



a) b)

Fig. 4 Company profiles: a) business sector, and b) application market.



a) b)

Fig. 5 Company profiles: a) size, and b) key customers structure.

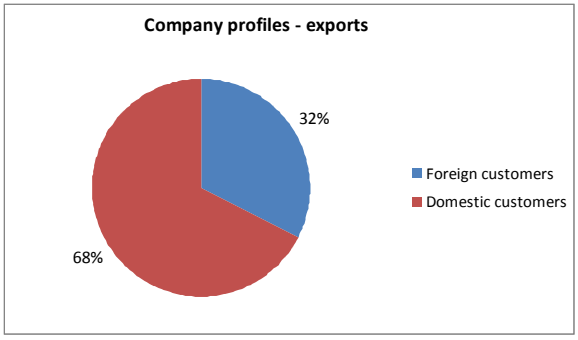


Fig. 6 Company profiles: share of exports.

2.2.2 Assessment of the market potential in Croatia

Due to a rather small number of companies that were analyzed, it is not possible to fully assess the market potential and future trends of cooperative systems technology in Croatia on the basis of acquired data only. However, under the assumption that the analyzed companies and their customers represent the actual market of cooperative systems reasonably well, a very rough end-user market potential estimate can be made based on four dominant application areas, Fig. 4.b.

Manufacturing industry

When it comes to manufacturing industry in Croatia, there has been a relatively steady decline in industrial production since the beginning of financial and economic crisis in 2008. Unlike the EU, where a relatively dynamic market recovery was observed within a period of 2 years, Croatia kept the negative trend and the industrial production index has fallen at an average annual rate of more than 2.6 %[12]. Between 2000 and 2012 the various sectors in manufacturing developed quite differently in the EU-28 and in Croatia, which is mainly related to a different structure of the Croatian manufacturing sector compared to the European average. Sectors that experienced significantly higher growth rates compared to the EU-28 average are paper products, machinery and repair&installation sector. Positive growth rates were also observed in the food sector and in transport equipment manufacturing.

[12] Production and turnover trends in Croatia and in the European Union, EUROSTAT report, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Production_and_turnover_trends_in_Croatia_and_in_the_European_Union#Industry

In the context of recent European Technology Platforms (ETPs), this application area can be connected to the "Production and Process" framework[13], where several ETPs that could be interesting for the application of cooperative technologies have been launched, such as "Future Manufacturing Technologies – Manufuture", etc.

Energy

The energy application area that is of primary interest for the application of cooperative technologies in Croatia (with established technology providers) can be roughly classified into three groups: renewable energy (wind and solar power, biomass, cogeneration, etc.), energy efficiency technologies and general power sector applications. The end-user market is somewhat different for each case: whereas private investors dominate the renewable energy market, the spending sources in the energy efficiency field are distributed between the public sector, local government, households, etc. It is expected that the total spending in both application areas will grow in the next 5-year period as a result of EU-driven projects as well as private investments.

As of early 2013 Croatia generates around 15.8% of its energy from renewable sources. Recently, the Croatian government adopted a national action plan for renewable energy sources until 2020 which shifts the focus from wind farm construction to energy production from biomass, biogas, cogeneration plants and small hydroelectric power plants, with a total incentive costs of approximately 1.8 billion €[14].

When it comes to ETPs within the "Energy" framework, the platforms[15] that are of potential interest to ACROSS and the Croatian cooperative energy applications market are related to photovoltaics (EU PV TP), wind energy (TPWind), renewable heating & cooling (RHC) and future electricity networks (SmartGrids).

Transport

Croatia has a long tradition and well-established technology providers in the field of transport systems and equipment manufacturing in the railway, marine and automotive sectors. Due to distributive nature of such systems, they are strong candidates for the application of cooperative technology.

Overall, the transport equipment manufacturing sector in EU had strong and continuous growth in the period 1997-2007 (index of production rose 3.9% per year), and kept its positive trend in the last years despite the effects of economic and financial crisis[16]. Recently, positive growth rates have also been observed for the transport equipment manufacturing sector in Croatia.

It is expected that this market will also benefit from the Croatian EU membership in the upcoming years due to investments in transport infrastructure through EU regional policy funds, such as ERDF and cohesion funds.

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[13] http://cordis.europa.eu/technology-platforms/ectp_en.html

[14] Government adopts national action plan for renewables, Croatian Government News and Announcements, http://www.vlada.hr/en/naslovnica/novosti_i_najave/2013/listopad/vlada_usvojila_nacionalni_akcijski_plan_za_obnovljive_izvore_energije_do_2020

[15] http://ec.europa.eu/energy/renewables/platforms_en.htm

[16] Transport equipment production statistics - NACE Rev. 1.1, EUROSTAT report, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Transport_equipment_production_statistics_-_NACE_Rev._1.1

Recently, several ETPs have been launched within the "Transport" framework that could be related with existing technology providers and end-users of cooperative transport systems technology in Croatia. The ETPs cover railways and infrastructure (ERRC[17]), road transport (ERTRAC[18]) and water transportation (Waterborne[19]).

ICT

In 2012 a total value of Croatian ICT sector was estimated at 820 million €, which corresponded to 4.2% share in country's GDP[20]. Similar to other industrial sectors in Croatia, the ICT sector was also strongly affected by the financial and economic crisis. It is expected that the pre-crisis 2008 ICT spending levels could be regained until 2017, depending on the overall recovery of Croatia's economy[21]. Over the period of 2013-2017 it is expected that the government sector would be the leading spender of ICT goods and services, mainly due to EU-driven modernization projects. Large telecom companies are also expected to remain among dominant spenders in Croatian ICT sector within the next 5-year period.

According to recent studies[22], several ICT research priorities have been identified based on their future potential for Croatia. Among those, research areas that are of particular interest for the application of cooperative systems are ICTs for health and e-health, security technologies and grid (distributed computing) technologies.

Regarding the ETPs within the "ICT" framework, the platforms that are of high potential interest to ACROSS centre and the Croatian ICT applications market are related to embedded systems (ARTEMIS[23]), robotics (EUROP[24]), smart system integration (EPoSS[25]) and wireless networks (Net!Works[26]).

[17] http://cordis.europa.eu/technology-platforms/errac_en.html
[18] http://cordis.europa.eu/technology-platforms/ertrac_en.html
[19] http://cordis.europa.eu/technology-platforms/waterborne_en.html
[20] Invest in Croatia, booklet, Agency for Investments and Competitiveness (AIK Invest), http://www.aik-invest.hr/en/
[21] Croatia Information Technology Report 2013, Business Monitor International, January 2013, online: http://www.marketresearch.com/Business-Monitor-International-v304/Croatia-Information-Technology-7308655/
[22] Final Strategic Research Agenda: ICT research priorities for Croatia 2009-2013, Background report, The Western Balkan Countries (WBC) INCO-NET, http://wbc-inco.net/object/event/6078/attach/Croatia_Final_Report_2008-12-07.pdf
[23] http://cordis.europa.eu/technology-platforms/artemis_en.html
[24] http://cordis.europa.eu/technology-platforms/europ_en.html
[25] http://cordis.europa.eu/technology-platforms/eposs_en.html
[26] http://cordis.europa.eu/technology-platforms/networks_en.html

3 Business clusters and competitiveness clusters in Croatia and opportunities for collaboration

3.1 Clusters in Croatia

In last decade numerous business clusters have been formed in Croatia due to direct state support to the clusters activities. More than 30 business clusters where in place in 2011. Most of them have been formed in low-technology sectors and poorly managed[27].

Croatian Ministry of Economy and Ministry of Entrepreneurship and Crafts initiated a program of development of Croatian Competitiveness Clusters and setting Cluster Development Strategy 2011-2020. The strategic goal of the competitiveness clusters is to identify innovative, synergistic projects of national importance which will help to give participating businesses an opportunity to become first in their field, both in Croatia and internationally.

The program was supported with an EU (IPA IIIc program) project "Support to Clusters Development"[28]. The project was completed in spring 2013 and resulted with a framework for national cluster policy and setting-up a few clusters of competitiveness.

Within strategic planning and setting economic policy agenda, Ministry of Economy of the Republic of Croatia defined 12 priority sectors[29] and initiated establishment of the corresponding competitiveness clusters: food production, wood production, automotive industry, maritime industry, defence industry, creative industry, ICT industry, textile and footwear production, pharmaceutics and medical equipment, chemical industry, manufacturing of electrical and mechanical equipment. Agency for Investments and Competitiveness[30] provides direct administrative support to the clusters.

Sectors such as: automotive, ICT, medical equipment, electrical and mechanical equipment are of high interest for ACROSS Centre. Members of ACROSS team are involved in setting up and management of some of the competitiveness clusters[31].

3.2 Croatian Competitiveness Cluster and technology platforms, ICT sector example

Ministry of Economy of the Republic of Croatia defines competitiveness cluster as[32] " a sector specific non-for-profit organization which brings together commercial, scientific and policy making communities in a formal structure. The intention is to gather the best players in their fields – SMEs and large companies, public institutions and science and research institutes in order to develop synergies and cooperative efforts. The final outcome of this synergy will be increased national sector competitiveness. … Competitiveness Clusters have been identified and established on the initiative of the Government of Croatia as instruments and support for strengthening the competitiveness of the private sector."

[27] The Analysis Of Regional Cluster Development In Europe And Croatia, http://ideas.repec.org/p/wiw/wiwrsa/ersa11p1708.html
[28] http://www.razvoj-klastera.hr/en/
[29] http://www.klasteri-konkurentnosti.hr/EN/
[30] http://www.aik-invest.hr/
[31] http://www.klasteri-konkurentnosti.hr/EN/Cluster/Home/11/
[32] http://www.klasteri-konkurentnosti.hr/EN/

The clusters will have important role in sector strategic planning and defining priorities for funding from EU Structural Funds. Clusters are involved in process of preparation of smart specialization strategy of Croatia which will highly influence future funding and regional development in Croatia.

The clusters will also have important role in setting up national technology platforms. Technology platform definition in context of Croatian Competitiveness Clusters differs somewhat from the definition of EU technology platforms (for EU technology platforms see section 1.2). It is defined as[33]: "Technology platform is an interest group constituted by business, public and science and research stakeholders in a certain territorial unit which work together to develop and efficiently utilise scientific infrastructure.

Science and research structure enables the application of new technologies and commercialisation of innovation to enhance competitiveness of one or several industrial sectors and Croatian economy altogether. Institutions which take part in the concept of technology platforms are interconnected with the communicational platform. Technology platforms of the Republic of Croatia are parts of High-Technology network for the industry of the Republic of Croatia and work parallel to regional and EU technology platforms."

The Croatian Competitiveness Cluster of ICT sector has been in process of preparation of Strategic Directions of the ICT sector (end of November 2013). It is expected that the process of establishment of national technology platforms will start in early 2014. ACROSS Centre is in close cooperation with the ICT Competitiveness Cluster through persons involved in Cluster management and interaction with its' key industrial partners (Ericsson Nikola Tesla and Končar whose managers are members of the Cluster Management Board) as well as firm connections with leading Croatian SMEs in the field of ACROSS expertise (reviewed in section *2*).

Besides ICT national platform, there are other initiatives in which ACROSS Team members are actively involved. For example, Croatian Smart Grid Technology Platform is in process of formation (end of November 2013, Chair: Prof. Davor Škrlec, ACROSS Team member). ACROSS Centre and Ministry of Economy jointly organized Workshop for Preparation of Croatian Technology Platform for Cooperative Renewable Energy Systems and Smart Grids, 2 July 2013. Also, UNIZG-FER and industrial partners (Ericsson, Končar Institute, Xylon, Mikroporjekt, AVL-AST, Systemcomm) encouraged Ministry of Science Education and Sports to support Joint Technology Initiative ECSEL, Electronic Components and Systems for European Leadership[34].

[33] http://www.klasteri-konkurentnosti.hr/EN/Info/What_Are_Technology_Platforms/
[34] http://ec.europa.eu/research/press/2013/pdf/jti/ecsel_factsheet.pdf

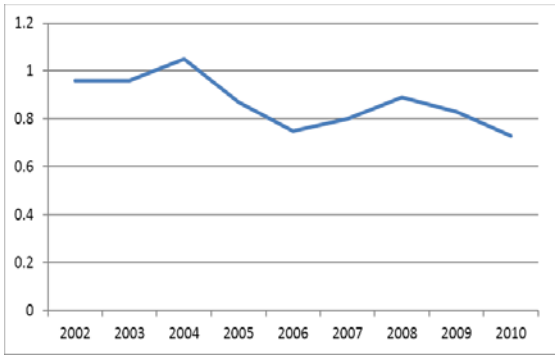
4 Sources of financing R&D&I in Croatia[35]

Abbreviations

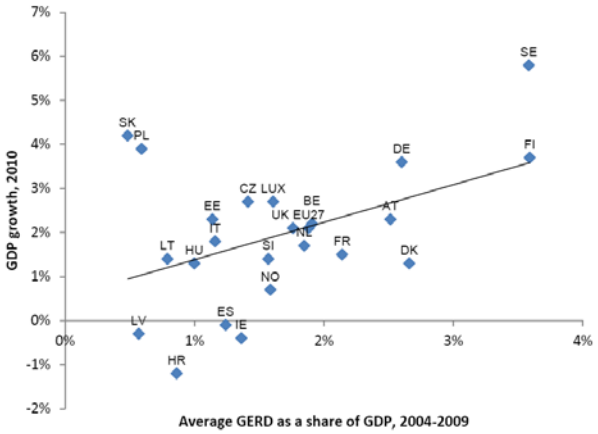
BERD	Business Expenditure on Research and Development
BICRO	Business Innovation Agency of Croatia
CRANE	Croatian Business Angels Network
CBS	Croatian Bureau of Statistics
CSF	Croatian Science Foundation
GERD	Gross Expenditure on Research and Development
HAMAG	Croatian Agency for SMEs
HIT	Croatian Institute of Technology
H2020	Horizon 2020
MoE	Ministry of Economy
MoEC	Ministry of Entrepreneurship and Crafts
MoSES	Ministry of Science Education and Sports
SIIF	Science and Innovation Investment Fund
UKF	Unity through Knowledge Fund

4.1 General statistics on R&D funding

Gross expenditure on R&D (GERD), measured as a percentage of GDP, is one of the most widely used indicators of an economy's relative degree of investment in generating new knowledge. Overall investments in R&D in Croatia for a period between 2002 and 2010 are shown in Fig. 7.a (source: Eurostat).



a)



b)

Fig. 7 a) GERD in Croatia, 2002-2010, and b) R&D investments in 2004-2009 and GDP growth in 2010

[35] Draft Background Report on the Innovation System of Croatia, OECD, presented November 2012

Croatia's total expenditure on R&D in 2010 was significantly below the EU27 average of 2% of GDP. As shown in Fig. 7.b, the countries that had invested more in R&D between 2004 and 2008 are also the ones that achieved higher GDP growth and thus faster recovery from the effects of global crisis. This may suggest that investment in R&D is a long-term and more stable driver of growth which helps economies to avoid major and prolonged economic downturns. The structure of R&D funding sources in Croatia in 2010 is shown in Fig. 8.

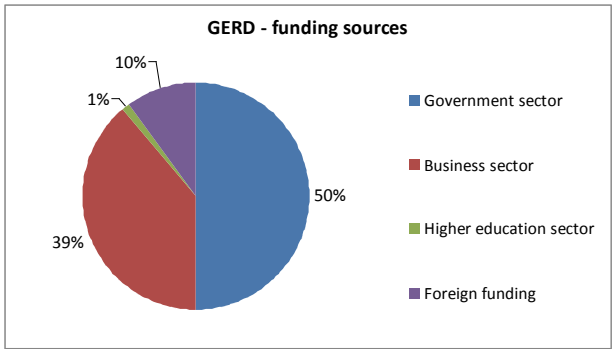


Fig. 8 GERD by sources of funds in 2010 (source: Eurostat)

As shown in Fig. 8, the government and the higher education sector together funded 51% of total R&D. In parallel, the business sector funded about 39% of total R&D. Finally, resources from abroad accounted for about 10% of GERD in 2010. The majority of foreign funds came from the private sector for joint ventures in the pharmaceutical industry and from the EU Framework Programmes (FP6 and FP7) [36].

When it comes to business expenditure in R&D (BERD), Croatia has been experiencing a strong decline in business R&D investment in the recent years, which can be partly explained by the effects of a global crisis, Fig. 9. BERD is concentrated in a very limited number of sectors (Fig 10) and in a few multinational companies in the pharmaceutical, telecommunications, agricultural and the food and beverage industries.

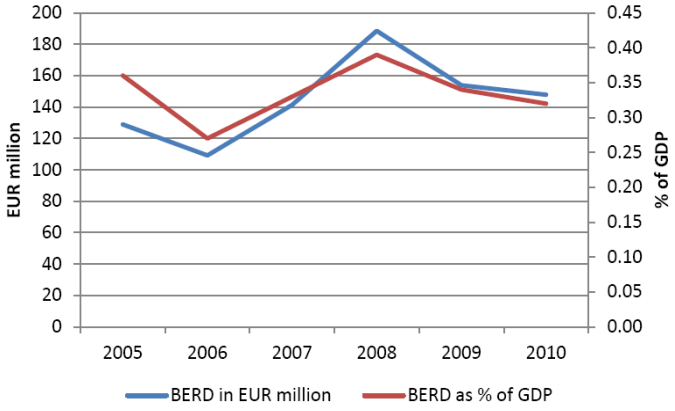


Fig. 9 BERD in Croatia, 2005-2010 (source: Eurostat).

[36] Švarc J. and D. Račić (2011), ERAWATCH Country Report 2010: Croatia, European Commission., http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/reports/countries/hr/report_0003

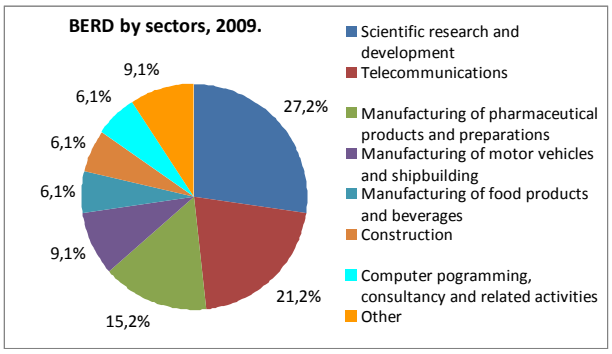


Fig. 10 BERD by sectors in 2009 (source: Eurostat)

4.2 Key R&D performers – funding structure

4.2.1 Business sector

Own funds are the most common source of finance for R&D activities in Croatian companies, Fig. 11. On the other hand, only a very small share of innovators had access to EU funds.

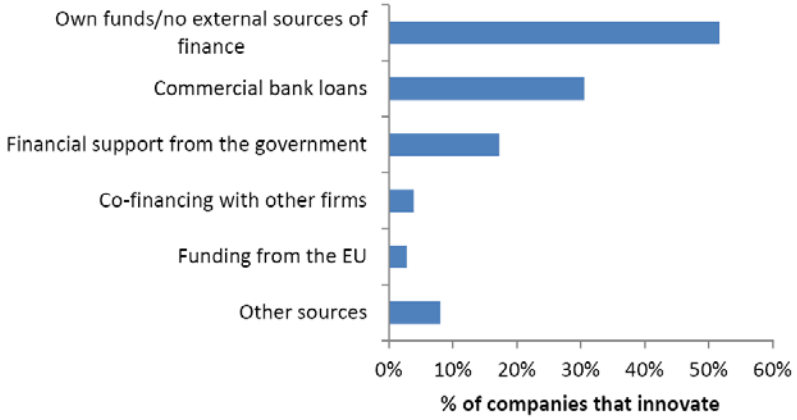


Fig. 11 Sources of R&D funding in Croatian companies (CIS, 2012)[37]

The small size of most Croatian companies combined with their reliance predominantly on in-house funds may explain the low share (35%) of companies devoting any financial or human resources to R&D. This is very much the case for non-exporting companies among whom only less than 25% invest in R&D at all.

4.2.2 Research institutions

Public research activities in Croatia are predominantly financed by budget resources allocated by the Ministry of Science, Education and Sports[38] (MoSES) through the four main channels:

- institutional funding (27% of total funds)
- competitive research grants (10% of total funds)
- junior researchers programmes
- other research supported programmes

[37] Community Innovation Survey (CIS), http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/cis
[38] http://public.mzos.hr/Default.aspx?sec=2428

The structure of funding sources for higher education institutions (universities, polytechnics and colleges) is shown in Fig 12. The government finances about 80% of research at universities, while enterprises (both public and private) finance about 10% of university research (CBS, 2012). Less than 7% of research activities in higher education institutions was financed by own funds in 2010, while the remaining resources came from foreign investors (2.8%) and non-profit institutions (0.2%).

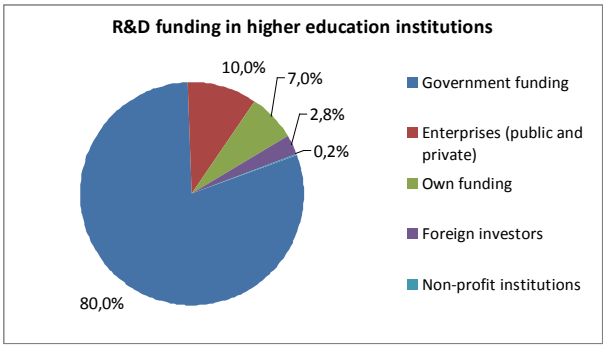


Fig. 12 Sources of R&D funding in higher education institutions (source: CBS, 2012).

The structure of funding sources for public research institutes is shown in Fig 13. About 84.2% of R&D at public research institutes was funded by central and local government, while only 5.8% was funded from institutions within the sector. The remaining funds originated from foreign investors (4.9%), private and public enterprises (4.7%) and non-profit institutions (0.4%).

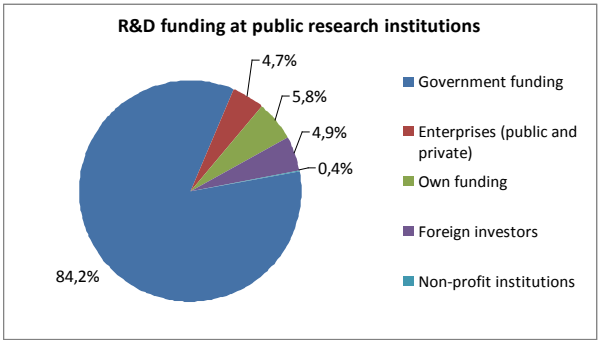


Fig. 13 Sources of R&D funding in public research institutes (CIS, 2012).

The structure of funding sources for private research institutes is shown in Fig 14. In 2010 around 69% of funds for R&D were derived from the resources of companies engaged in R&D, with a remaining 17% from foreign investors, 10% private and public enterprises, and only around 4% from central and local government.

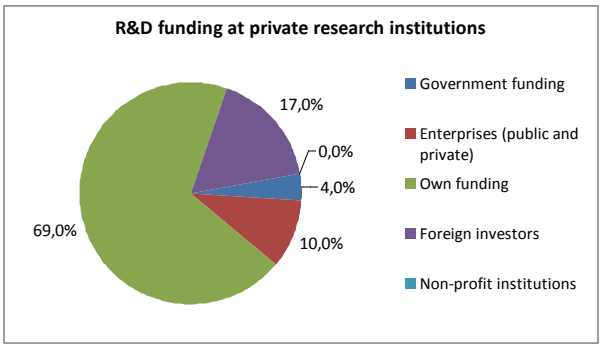


Fig. 14 Sources of R&D funding in private research institutes (CIS, 2012).

4.3 Public funding

The main government institutions and their key programmes that provide funding for R&D activities in Croatia are summarized in the sections below. In general, these are institutions responsible for the implementation and administration of specific government policies on science and technology, i.e. the Croatian innovation system.

4.3.1 Business Innovation Agency of Croatia (BICRO)[39]

The Business Innovation Agency of Croatia – BICRO was established by the Croatian Government in 1998 as a public limited liability company with the aim to develop financial incentives that will support innovation and technology-based businesses in Croatia. Today, BICRO acts as government agency with its primary role set at development and the implementation of government support programmes aimed at strengthening technology development.

R&D supporting programmes administered by BICRO include RAZUM, TEHCRO, VENCRO, IRCRO, KONCRO and Proof of Concept (PoC). In addition, BICRO is the implementation agency for EUROSTARS/EUREKA and several international cooperation programmes in Croatia. In March 2012, the Croatian Institute of Technology (HIT) was merged into BICRO. Therefore, BICRO further widened its scope of work with activities that were HIT's responsibilities, including the management of the TEST programme and the implementation of FP7 in Croatia.

RAZUM – The programme supports initial funding of newly established knowledge based companies, as well as funding of research and development of new products or services in existing companies.

TEHCRO – The programme supports commercialization of research outputs and the transfer of knowledge from universities and scientific institutions to business through development of technology business centres, technology incubators and R&D centres.

VENCRO – The programme supports the establishment of venture capital funds and the development of the venture capital industry.

IRCRO – The programme aims to encourage and stimulate the demand for services of public research institutions, as well as to encourage SMEs to invest in R&D activities. In the period 2007-2010, a total of 43 project applications were submitted for co-financing from the IRCRO programme. A total of 17 projects were approved for co-financing of HRK 13 million (around EUR 1.73 million). In 2011, six new projects were approved for co-financing from the IRCRO programme, with approved co-financing of just over HRK 3.5 million (around EUR 467,000).

KONCRO – The programme provides co-funding of consultancy services with the goal of increasing competitiveness of companies on the global marketplace.

PoC – The program is designed to support established and start-up businesses developing innovative new products and processes and to assist in the spinout of new enterprises from universities in Croatia by providing funds. The Fund supports the applicants to investigate, advance and protect early stage innovative business ideas. The Fund supplies grants, typically between 35 thousand and 350 thousand Kuna to support costs associated with

[39] http://www.bicro.hr/

commercializing new products and processes, and is supported by the Croatian Ministry of Science, Education and Sports, as well as The World Bank.

EUREKA – The programme supports market-oriented R&D and innovation projects by industry, research institutes and universities across all technological sectors.

EUROSTARS – The Eurostars Programme is an European innovation programme. It is managed by EUREKA. Its purpose is to provide funding for market-oriented research and development with the active participation of research and development - performing small - and medium-sized enterprises (R&D-performing SMEs).

TEST (formerly managed by HIT) – The programme is the prime instrument of providing government subsidies to applied research in the field of technology with the emphasis on encouraging hi-tech development. The TEST programme finances those research projects, launched by Croatian scientists which develop new technologies and which, following the completion of the research stage, aspire for further commercialization and new product or service creation. TEST statistics for the period 2007-2012 include 13 completed projects, co-financed with around HRK 18.5 million (around EUR 2.5 million) and 18 ongoing projects with concluded co-financing agreements and agreed co-financing of around HRK 28.4 million (EUR 3.8 million).

4.3.2 Science and Innovation Investment Fund (SIIF)[40]

SIIF was developed through the IPA programme to enhance technology transfer and the commercialisation capacities of higher education institutions and public research institutes. The programme supports innovation commercialisation in the public R&D sector in order to bridge the gap between the pre-commercial and commercial phases of R&D in Croatia, and thus create a productive environment where innovation capacity can develop.

4.3.3 Unity Through Knowledge Fund (UKF)[41]

The main mission of the UKF is to unify the scientific and professional potentials in Croatia and the Diaspora for the development of the Croatian society based on knowledge. The programme was launched by the Government of Croatia in 2007, represented by the MoSES and supported by the World Bank Loan.

In the period from December 2007 to March 2011, 80 scientific and technological projects were launched, 30 of which are still ongoing and the funds committed totalled over EUR 5.3m. In the same period 299 project proposals were submitted to all UKF Fund Programmes and the overall funds requested amounted to about EUR 30m.

4.3.4 Croatian Science Foundation (CSF)[42]

Croatian Science Foundation (CSF) was founded in December 2011 by the Croatian Parliament. Its mission is to promote science, higher education and technological development in Croatia in order to ensure the development of the economy and to support employment. CSF provides support to scientific, higher education and technological programmes and projects, fosters international cooperation, and helps the realisation of scientific programmes of special interest in the field of fundamental, applied and developmental research. From July 2012, the funding of scientific projects was transferred from the central public administration (MoSES) to the CSF as a professional institution.

[40] http://www.siif-croatia.com/en/
[41] http://www.ukf.hr/
[42] http://www.hrzz.hr/default.aspx?id=6

4.3.5 Agency for Mobility and EU Programmes[43]

The Agency for Mobility and EU Programmes is the national agency responsible for the implementation of the Lifelong Learning Programme and Youth in Action Programme in Croatia. It is also responsible for the implementation of Europass, Eurodesk, EURAXESS, Euroguidance and Erasmus Mundus. The Agency for has expanded its coverage of FP7 from the specific subprogramme *People* to a small portion of the subprogramme *Cooperation*, namely in the thematic areas *Energy and Environment*.

4.3.6 MoEC – SMEs supporting programs[44]

The MoEC implements the Programme for Supporting Small and Medium-Sized Entrepreneurship, which comprises several projects aimed at increasing competitiveness of Croatian SMEs, and accompanying yearly operational programmes:

The Innovation Development and Application project is aimed at providing support to increase the capacity for research and innovation, with the goal of the development of small and medium entrepreneurship. Support is provided to SMEs and associations of innovators in the form of grants by the MoEC. The budget in 2012 amounted to HRK 11 million.

Through the Increasing the International Competitiveness project, the MoEC provides financial support in the form of grants to SMEs for individual and joint participation on international fairs, enhancing the competitiveness through the development of new products, preparation activities for introduction of new or existing product to new markets, and the organisation of trade missions in international markets. The budget for 2012 amounted to HRK 25 million.

4.3.7 Croatian Agency for SMEs and Investments (HAMAG-INVEST)[45]

The Croatian Agency for SMEs and investments (HAMAG – INVEST) is an implementation agency that provides support to SMEs and implements measures focusing on financial incentives schemes and business advisory services through a network of certified consultants. The Agency also implements public guarantee funds and grants guarantees for loans given by commercial banks and other creditors focusing on financing fixed assets and working capital. The value of HAMAG's grant capital is EUR 65 million.

Within the New Technologies project, HAMAG allocated HRK 22.5 million (EUR 3 million) of budget resources for co-financing investments in the development and procurement of new technologies and application of knowledge in production processes. The lowest individual grant was HRK 50,000 (EUR 6,667) for micro enterprises and HRK 150,000 (EUR 20,000) for SMEs, while the highest individual grant amounted to HRK 250.000 (EUR 33,333) for micro enterprises and HRK 700,000 (EUR 93,333) for SMEs, with the co-financing rate up to 85% of eligible costs.

4.4 Funding from business sector

The major part of R&D funding from the business sectors comes from its participation in various programmes of public funding or EU funding (see section 4.1).

Direct funding of R&D activities by means of private equity and risk capital are practically non-existent in Croatia. VENCRO programme, launched by BICRO, seeks to finance

[43] http://www.mobilnost.hr/index_en.php
[44] http://www.minpo.hr/default.aspx?id=68
[45] http://www.investcroatia.hr/

innovative start-up companies by encouraging private investors to set up a public-private venture capital fund. However, due to the financial crisis, which reduced the interest of private investors, this programme has not been successfully implemented yet.

There is some business angel activity, done primarily through the Croatian Business Angel Network[46] (CRANE) and Zagreb Entrepreneurship Incubator[47].

4.5 EU funding

4.5.1 The EU Framework Programme for Research and Innovation (Horizon 2020)

Horizon 2020 is the financial instrument implementing the Innovation Union[48], a Europe 2020[49] flagship initiative aimed at securing Europe's global competitiveness. Running from 2014 to 2020 with an €79 billion budget, the EU's new programme for research and innovation is part of the drive to create new growth and jobs in Europe.

It will combine all research and innovation funding currently provided through the Framework Programmes for Research and Technical Development[50], the innovation related activities of the Competitiveness and Innovation Framework Programme (CIP)[51] and the European Institute of Innovation and Technology (EIT)[52].

4.5.2 Competitiveness and Innovation Framework Programme (CIP)

With small and medium-sized enterprises (SMEs) as its main target, the Competitiveness and Innovation Framework Programme (CIP) supports innovation activities (including eco-innovation), provides better access to finance and delivers business support services in the regions.

The CIP is divided into three operational programmes:

- The Entrepreneurship and Innovation Programme (EIP)
- The Information Communication Technologies Policy Support Programme (ICT-PSP)
- The Intelligent Energy Europe Programme (IEE)

Starting from 2014 CIP will be integrated into Horizon 2020 programme.

4.5.3 Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME)[53]

COSME is the EU programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (SMEs) running from 2014 to 2020 with a planned budget of €2.3bn. COSME will support SMEs in the following area:

- Better access to finance for Small and Medium-sized Enterprises (SMEs)
- Access to markets
- Supporting entrepreneurs
- More favourable conditions for business creation and growth

[46] http://www.crane.hr/
[47] http://zipzg.com/tag/zagreb/
[48] http://ec.europa.eu/research/innovation-union/index_en.cfm
[49] http://ec.europa.eu/europe2020/index_en.htm
[50] http://cordis.europa.eu/fp7/home_en.html
[51] http://ec.europa.eu/cip/
[52] http://eit.europa.eu/
[53] http://ec.europa.eu/enterprise/initiatives/cosme/index_en.htm

4.5.4 EU Structural and Investment (ESI) funds for Croatia, 2014 – 2020[54]

Provisional allocation for Financial Period 2014 – 2020 for Croatia (November 2013)[55] is approximately 8 billion Euro from ESI for:

- innovative and competitive business and research environment - more than 20%,
- energy efficiency, renewable energies and environmental protection - more than 30%,
- sustainable and modern transport networks and infrastructure - around 20%,
- quality and accessibility of education, increase labour market participation, reduce poverty, support active inclusion and effectiveness of public administration and judiciary -around 25%.

Ministry of Science, Education and Sports announces two kinds of projects for innovation capacities support[56]. Large (infrastructural) projects and smaller R&D&I projects aimed to close collaboration with industry.

[54] http://www.strukturnifondovi.hr/
[55] Matija Derk, How to Use EU Funds: Croatian Government Plan, EUSDR Conference, November 27, 2013
[56] Ivana Crnić Duplančić, Structural funds and innovation capacity strengthening (in Croatian), http://www.euraxess.hr/uploads/images/eurax927_era_chairs_ivana_cd.pdf

5 Long term R&D&I platform of the ACROSS Centre

5.1Context and objectives of the ACROSS technology platform

The Centre of Research Excellence for Advanced Cooperative Systems (ACROSS Centre) is an interdepartmental research centre at the University of Zagreb Faculty of Electrical Engineering and Computing (UNIZG-FER). Its establishment and operation is funded by the European FP-7 Capacities "Research Potential" program [285939, FP7-REGPOT-2011] for the 3-year period, from October 2011 to September 2014. The Centre research activities focus on four major Strategic Research Domains:

- Cooperative Cognitive and Robotic Systems;
- Cooperative Networked Embedded Systems;
- Cooperative Renewable Energy Systems;
- Cooperative Control Methods.

While the first three strategic research domains are application-oriented, the fourth strategic research domain is of paramount importance for advanced cooperative systems in general, as a fundamental enabling technology. Possible applications of these advanced cooperative systems are numerous: advanced flexible manufacturing, renewable and sustainable energy, home and office automation, transport, logistics, environmental monitoring, healthcare, security and surveillance, human augmentation etc.

The **Global Objective** of the ACROSS Research Centre is:

- to be at the forefront of research and development of novel methodologies and advanced engineering approaches for cooperative systems as well as
- to act as a point of contact between academia and industry, providing an infrastructure for scientific exchange in the area of cooperative systems related to robotics, networked embedded systems and renewable energy systems.

The ACROSS Team, which comprises fourteen research groups from seven UNIZG-FER departments, possesses the required multi-disciplinary R&D expertise for achieving the Global Objective. The Team is organised in four research teams, one for each strategic research domain. These teams have been formed according to the complementary expertise of research groups. The ACROSS Team tightly collaborates with sixteen leading EU research centres and three Croatian partner companies.

Expected impacts of the execution of the ACROSS Global Objective include:

- better integration in the European Research Area (ERA) with increased participation in FP7 collaborative research projects, and
- increased contribution to Croatian economic and social development.

The ACROSS contributes to a number of EU policies and initiatives:

- ACROSS contributes to the goal of Lisbon Strategy[57] and European Research Area (ERA)[58] of mapping research and technology excellence in Europe by networking centres of research excellence and integrating their research activities. – **How?**

[57] http://ec.europa.eu/growthandjobs/pdf/lisbon_en.pdf
[58] http://ec.europa.eu/research/era/pdf/era_gp_final_en.pdf

ACROSS has established strategic long-lasting networking/partnership with 16 excellent European research entities.

- ACROSS contributes to the EU initiative of the Regions of Knowledge which aims to strengthen the research potential of European regions, in particular by encouraging and supporting the development of research-driven clusters.[59] – **How?** A round table and a workshop on research-driven clusters have already been organised by the ACROSS Centre and dedicated workshops are all four ACROSS strategic research domains are planned for spring 2014.
- ACROSS is in line with the Treaty Article 171 on joint undertakings for the efficient execution of Union research, technological development and demonstration a programme[60] – **How?** Besides the UNIZG-FER as the single beneficiary partner in ACROSS, a total of 16 R&D groups from 10 European countries collaborate in its execution.
- ACROSS contributes to the EU policy of the Western Balkan Countries (WBC) integration in the EU[61] and is in line with WBC commitments to the principles of the European Charter given at Thessaloniki Summit 19-20 June 2003.[62] – **How?** ACROSS contributes to this commitment specifically concerning Croatian SMEs, helping them to share good practice with other European countries.
- ACROSS also contributes to other EU policies such as External Relations. During the conference at the European Parliament on 3rd February 2005 to examine WBC participation in the EU research framework programmes, the EU's Science and Research Commissioner, Janez Potocnik, said "There is a need for strong research institutions and trained researchers in the Western Balkans." – **How?** UNIZG-FER is a leading Croatian research and educational institution in Electrical Engineering and ICT and has been at the forefront of research and education in the Western Balkans since 1950s. ACROSS has already unlocked and developed UNIZG-FER research potential by recruiting 18 researchers (4 researchers return from abroad) and acquiring state-of-the-art research equipment, which has already resulted with significant participation in research activities at EU level, i.e. its better integration in ERA. Currently, ACROSS researchers are coordinators of 2 FP7 projects and partners in 5 FP7 projects, with total budget (our share) of more than 5 million Euro.

ACROSS Centre has also significantly contributed to Croatian economic and social development in various ways, mostly through various dissemination events to interested national stakeholders (other R&D groups, end-user community, large industry and SMEs, governmental bodies and general public). The most important events we (co)organised are:

- ACROSS round table on Coordinated use of the Framework Programme and Structural Funds for research and innovation strategy development and implementation, 24th February 2012.
- ACROSS round table on Networking for preparation and setting up research driven clusters for cooperative systems, 26th June 2012.

[59] http://cordis.europa.eu/fp7/capacities/regions-knowledge_en.html
[60] http://www.lisbon-treaty.org/wcm/index.php
[61] "The Western Balkans and European Integration", Communication from the Commission to the Council and the European Parliament, COM(2003) 285, Brussels 21.05.2003. http://www.see-educoop.net/education_in/pdf/comm-from-com-1--oth-enl-t02.pdf
[62] Thessaloniki Summit 19-20 June 2003: Western Balkans - Council Conclusions, The Thessaloniki agenda for the Western Balkans, Annex A. http://www.becei.org/DOKUMENTI/balkans_conclusions.htm

- ACROSS Joint Workshops on Structural Funds and Research Driven Clusters, 21st of November 2012.
- Invited talk (Vedran Bilas on behalf of the ACROSS Centre) on International Conference "Clusters for Innovation and Growth in the Republic of Croatia", Ministry of Entrepreneurship and Crafts, EU IPA IIIc 2007 project Support to Clusters Development, April 18 2013. The Conference demonstrated recent progress in cluster development in Croatia and presented proposed policy initiatives. Key members of the cluster community discussed how better use of ''clustering'' by triple helix partners can contribute to the development of new enterprises, greater levels of technology, increased employment and the development of new export markets for Croatian products.
- Workshop for Preparation of Croatian Technology Platform for Cooperative Renewable Energy Systems and Smart Grids, 2 July 2013, organised by ACROSS Centre in cooperation with the Ministry of Economy of the Republic of Croatia.
- Co-organization and invited talks (Nedjeljko Perić, Maja Matijašević, Mario Vašak), International Conference on "Research and Entrepreneurship Partnership for Growth and Internationalization of SMEs in the Danube Region", November 27-28, 2013. (http://groupspaces.com/Competitiveness/item/504316).

Croatia is, by European standards, a small country with about 4.3 million inhabitants. Its pool of researchers is not large – according to the latest data there are about 5800 Doctors of Science and about 2000 junior researchers. Solutions are sought for the problem of "brain drain" and there is also a major need for investment in research infrastructure. As for the national R&D funding, according to the Eurostat[63] data, the gross domestic expenditure on R&D (GERD) in Croatia expressed as a percentage of GDP has been about 0.7 – 0.8 % in last several years, which is below the needed level of funding even to maintain the current level of research activities, and absolutely not sufficient to provide for a much needed push to bring out the full potential of the Croatian research community. It is, therefore, very difficult for any Croatian research entity to significantly increase the level of its research activities and aim to achieve world-class research results without the EU funding. That is why the UNIZG-FER, as the leading Croatian R&D institution in the fields of electrical engineering and ICT, proposed the ACROSS project and established the ACROSS Centre of Research Excellence for Advanced Cooperative Systems with its four strategic research domains.

In the ACROSS project proposal, submitted to the FP7-REGPOT-2011 Call in December 2010, we have presented the long-term research strategy of the Centre and the means of its implementation. However, in order to help sustainability of the Centre after the project completion we also included the task of writing this document ("Whitepapers on technology platform preparation on four SRDs and commercial potential evaluation in Croatia" – *ACROSS whitepaper*) in the ACROSS work plan.

The **main objective** of the *ACROSS whitepaper* is to update and revise R&D&I strategy of the ACROSS Centre and to further strengthen its integration in the European Research Area and contribution to Croatian economic and social development. The *ACROSS whitepaper* follows the European Platform concept, i.e. the *ACROSS whitepaper* concept is devised to contribute to competitiveness, to boost research performance and to concentrate efforts and address fragmentation. To that end, in the next sections we present: (i) long-term R&D strategy, (ii) international competitiveness, (iii) contribution to economic and societal

[63] http://epp.eurostat.ec.europa.eu/

development of Croatia and technology transfer, and (iv) long-term substantiality of the ACROSS Centre.

5.2 Long-term R&D strategy of the ACROSS Centre

The ACROSS Centre has enabled research in its four Strategic Research Domains (SRDs) at a much higher level than it was possible before its establishment, and the purpose of this *whitepaper* is to device roadmap to further boost research performance of the Centre. In the end this will "pay dividends" to the UNIZG-FER, local community, Croatia, and the EU. In particular, we expect significant improvement of our research activities in both the theory of cooperative control, which is a fundamental enabling technology for advanced cooperative systems, and in application-driven research oriented towards the needs of the end-users as the prime market drivers of all R&D globally.

The **long-term overall RTD objective** of the ACROSS Centre is to be at the forefront of research and development of novel methodologies and engineering approaches for advanced cooperative systems, particularly focussing on three major application-driven research domains:

- SRD1 - Cooperative Cognitive and Robotic Systems,
- SRD2 - Cooperative Networked Embedded Systems,
- SRD3 - Cooperative Renewable Energy Systems.

The potential of these three strategic research domains for national economic and societal development has been recognised (see section 2.2) and ACROSS Team has a proven high-level track record in these domains. We would like to strongly boost these expertises in order to successfully participate in research activities in these domains at the EU level and to significantly contribute to the sustainable economic and social development of Croatia.

We have included **Cooperative Control Methods** as the fourth ACROSS' strategic research domain (SRD4), focusing on theory and methodologies to devise novel and well-founded solutions for cooperative systems, given availability of an infrastructure technology. The aim of cooperative control is to provide a systematic approach to problems in a general class of cooperative systems. To this end, cooperative control designs modelling, prediction, control, planning, learning, and design-from-specifications tools for cooperative systems.

The RTD objectives are better served by a synchronised and integrated execution of research activities in all four SRDs, since each SRD can benefit from research results obtained in other SRDs. On a first glance, the three ACROSS' application-oriented research domains are quite diverse. However, there are a lot of interrelated and complementary research topics. Besides the cooperative control methods, of common interests are also wire(less) sensor/actuator embedded networks as hardware enabling technology for cooperation and communication and signal and information processing and fusion methods as "soft" enabling technologies for cooperation.

Hereafter, we device the long-term research strategy of the ACROSS Centre in its four SRDs by taking into account: (i) the state-of-the-art and future perspectives in ACROSS SRDs, (ii) the RTD objectives as well as existing expertises and research accomplishments of the ACROSS Team members.

5.2.1 Cooperative Cognitive and Robotic Systems (SRD1)

ACROSS R&D strategy in cognitive and robotic systems aims to extend systems engineering to the design of **individual and cooperative robotic systems** that can carry out various useful

tasks in different application scenarios, such as manipulation and grasping, exploration and navigation, monitoring and control, situation assessment, communication and interaction, autonomously or in cooperation with people and/or distributed smart environments.

The presence of uncertainties, incomplete information, distributed control, and asynchronous computation will be accounted for when performing trajectory tracking, formation-keeping control, and collision avoidance, or allocating tasks, communication, coordinating actions. One way to resolve the above challenges is **cooperative control**, since it allows development of complex behaviour based on several controllers combined to achieve the desired result.

ACROSS long-term strategy will focus on achieving significant research results in the area of cooperative control of robotic systems, with emphasis on cooperation between heterogeneous agents operating on ground, in air and in/on water. In order to achieve this complex task, high level mission planners with optimal allocation will be developed – these planners will contribute to increased efficiency of cooperative systems, as well as decreased power and resource consumption.

ACROSS long term strategy in the area of human-robot cooperation will focus on establishing seamless interaction with cognitive systems in order to assist people in everyday activities and work. In order to achieve high level of autonomy, ACROSS will focus on transferring state-of-the-art perception methodologies to 3D environments. In the area of mobile manipulation, ACROSS long term strategy is to enable mobile manipulation between heterogeneous units.

Heterogeneity of cognitive robotic systems and their interaction with humans increases complexity, but also has an advantage of complementing human capabilities with perception and actuation abilities of robots. However, formal methods to address the optimal real-time cooperation of autonomous robots and humans, exploiting their complementary capabilities, will also be researched.

5.2.2 Cooperative Networked Embedded Systems (SRD2)

ACROSS R&D strategy in networked embedded systems aims to develop new methods and algorithms to support cooperation schemes of embedded sensing systems in smart environments. The research will be directed towards smart, communicating, energy-efficient devices to provide universal in-home and mobile access to information and services. More specifically, our research will focus on: (1) sensors for smart environments, (ii) energy transfer and harvesting solutions, (iii) Big Data produced by Internet-connected objects, and (iv) Cloud environments.

In the area of **sensors for smart environments** new sensor solutions for different environmental needs will be sought, with the following technologies under consideration: miniaturized electromechanical sensors, optical sensors, RFID-based sensors etc. In order to successfully develop the whole sensor networks propagation mechanisms will be investigated. E.g., human on-body and in-body propagation effects will be investigated in order to provide a realistic channel model.

The next generation of smart environments requires developing innovative **energy transfer and harvesting solutions**. The research will be targeted to pervasive sensing with cooperation of energy efficient distributed sensor platforms and mobile devices. Hardware research includes wireless energy transfer and RF energy harvesting circuits, conversion/storage techniques; and energy consumption optimisation of communication and sensing. Especially important and worth will be to weigh between lowering data throughput with related energy cost and raising quality of complex systems control that requires the data

rate from sensors as high as possible. Research on software solutions will be aimed to context- and energy-aware multimodal sensing and signal processing, energy management techniques, control and prediction algorithms.

In order to enable real-time processing of **Big Data produced by Internet-connected objects**, highly scalable and elastic data management systems as well as programming models will be developed. Primarily Cloud environments will be targeted. Research will focus on methods for analyzing and modelling the dynamics of sensed data to observe large-scale phenomena with the aim to extract knowledge from such data as well as to serve the information of interest to end users in near real-time.

The research will include highly scalable, elastic and autonomic data management systems and programming models for real-time processing and analytics of Big Data produced by Internet-connected objects. We will put in question the traditional windowing model for limiting the temporal scope of continuous queries and develop theoretical principles needed to scale real-time processing algorithms to massive data streams, targeting primarily **Cloud environments** where service elasticity needs to be supported. We will research methods for analyzing and modelling the dynamics of sensed data to observe large-scale phenomena with the aim to extract knowledge from such data as well as to serve the information of interest to end-users in near real-time. Here we need to solve fundamental problems related to data sampling, sensor mobility and data redundancy to achieve required sensing coverage as well as design novel knowledge-based and automated reasoning techniques to extract meaning from streaming data in real-time. In addition, filtering techniques limiting the frequency of notifications being sent to user devices need to be tested for wide adoption.

The networked embedded systems often have complex and dynamic goals with a great deal of autonomy. They have to cope with failures and uncertainties with recovery through reconfiguration or self-restructuring. Therefore, in a system composed of components which are interconnected by communication network, the subsystems should be able to cooperate between themselves as well as recognize system failure states. Such behaviour has features that appear in multi-agent systems. Consequently, one can utilize the multi-agent algorithms of **cooperative control** and optimization.

5.2.3 Cooperative Renewable Energy Systems (SRD3)

ACROSS R&D strategy in the field of renewable energy systems aims to extend systems engineering to design more efficient energy conversion and to lower the cost of renewable energy sources. Additionally, there is a very challenging task how to ensure the best integration (cooperation) of distributed energy generators and storage devices, organized as a **microgrid**, with utility grid using dynamically reconfigurable ICT architectures, technologies and tools. To ensure this, **new proactive cooperative control systems** based on platforms integrating (near) real-time information from wireless sensor networks and external information systems, such as weather forecasts, should be designed.

In a typical microgrid, several types of renewable energy producers competitively and cooperatively provide power to both local loads and the main grid. It is well recognized that these distributed energy sources are intermittent, that their presence will shift the operation of power system from the current mode of regulated utilities to a competitive generation provision, and that a high penetration level of these sources demands new regimes of measurement and estimation, communication, control, protection, security, and operation.

Multi-agent algorithms of **cooperative control** and optimization should be implemented to enable robust, intelligent and efficient operations for power systems with distributed and intermittent power generation sources. Specifically, the following three-layered control-

optimization-control structure is proposed: (i) a cooperative control algorithm that enables autonomous formation and evolution of microgrids as distributed generation changes over time, (ii) each of the self evolving microgrids negotiates (as an agent) with the main grid to determine the best operating conditions by following the incentives (and limits) specified by the main grid and by maximizing the group energy output, and (iii) in the event of a major fault, the main grid can intervene such that the available distributed power generation sources are used as transient control inputs to maintain stability of the overall power system.

It is relatively straightforward to apply a cooperative control algorithm for distributed renewable energy systems such that microgrids are formed autonomously depending on communication and data sharing and that the utilization percentages of all units in the microgrid are the same. Such a cooperative algorithm would autonomously form microgrids and align the economic interests of distributed generation sources within the same micro-grid, effectively becoming an impartial virtual leader. Indeed, the cooperative algorithm naturally handles load sharing and can be further enhanced to have such protection functionality as anti-islanding.

5.2.4 Cooperative Control Methods (SRD4)

For more than fifty years, control theory has been dominated by a centralized paradigm, where all measurements are processed together in order to compute the control signals. This paradigm has conceptual advantages, but also inherent limitations. In particular, industrial practice often relies on distributed control structures and there is a strong need for more systematic approaches to design distributed and cooperative controllers that take into account the distributed information. During the last ten years or so, some very encouraging progress has been reported, which has significantly raised expectations for future progress in the area of cooperative control. Compared to the centrally governed designs, cooperative control architectures are more tolerant to communications failure and subsystems malfunction as they can proliferate data across redundant networks of agents and more rapidly isolate the faults. The control system relies on discrete elements, or agents, to act as local subsystem controllers to meet local objectives while making their decisions known to other agents.

Multi-agent systems approach to distributed control systems is widely spread for important utilities it provides. They offer a decentralized control model based on agents. By integrating these two lines of research - the multi-agent systems and the cooperative control approaches - results in **a multi-agent architecture of cooperative control**. In this approach several agents cooperate with each other to reach their individual goals, while ensuring that individual goals sum up to the final goal for the whole system. Since the multi-agent system is inherently multi-threaded, each agent has its own thread of control; each agent decides whether or not to perform an action on request from another agent (autonomy); and each agent exhibits a reactive, proactive and social behaviour (flexibility). In addition, no centralized arbiter is defined, but the coordination of all the agents achieving a common goal is peer to-peer based. Therefore, the tasks to be accomplished to achieve a global goal are distributed between agents and each agent is to perform its special task (each agent in the system has its own control block).

ACROSS Team has strong background in modelling and control of hybrid systems, i.e. systems that consist of discrete and continuous components. Hybrid systems model the interactions between logical elements and continuous systems. This includes a variety of mathematical and engineering disciplines such as differential geometry, differential and difference equations, optimal control, automata theory, discrete event systems, data structures, and computation. This is a new phenomenon for control engineers and computer scientists. Hybrid systems are not only hard to model but also hard to analyse and control. However,

nowadays advanced solutions are in use to solve the modelling and control problem of this kind of systems, increasingly.

Because of complexity of hybrid systems, problems that have similar requirements have been decomposed and modelled as systems of multiple interacting intelligent agents. Multi-agent systems can develop flexible intelligent behaviour and coordination schemes, but their solutions are not easily represented or analysed mathematically. To fully utilize the multi-agent system representation capabilities a new agent framework is proposed that makes agents dynamically accessible for control design.

Our research focuses on the modified multi-agent framework of cooperative control where the optimal controller of a hybrid system is embedded in the core of an agent. The abstract "agent state" is replaced with a hybrid automata and a controller, while the "agent process" retains its intelligence and coordination function. This makes it possible to represent systems with multiple modes and to design suitable control laws that are valid for each of these modes. Moreover, existing mathematical tools (e.g., from the theory of discrete event systems) can be used to describe and analyze systems based on this kind of agent framework.

5.3 International competitiveness of the ACROSS Centre

Focusing its research activities on fundamental enabling technologies for future implementation and application of advanced cooperative systems, and building upon its high level of research team expertise and achievements thus far, ACROSS Centre aims to become a regional leader and a highly competitive research centre at EU level and worldwide. Advanced cooperative systems will enable many new applications in major socially and environmentally relevant application areas.

The ACROSS key scientists, with their research groups, together form a strong team capable to reach the objectives stated in this proposal. They are experienced in their domain of expertise, and have research and development achievements internationally recognized by the research community. Each involved scientists is highly committed to the ACROSS objectives and the collective resources are well-planned and appropriate for realizing the stated goals. The pertinent management structure and procedures have been developed to ensure efficient, flexible, robust, and proactive management of the Centre.

ACROSS Centre has already participated in a significant number of international and national projects, and initiatives in the strategic research domains addressed by ACROSS (ongoing EU FP7 projects are listed below). We take account of these projects and initiatives, and well established international cooperation on them, in devising the ACROSS R&D strategy in section 5.2 and we expect that the implementation of the strategy will significantly boost the research capacity and capability of the ACROSS Centre in cooperative and cognitive systems, thus resulting in worldwide competitive research accomplishments.

The ongoing EU FP7 research projects:

1. *ACROSS – Centre of Research Excellence for Advanced Cooperative Systems***,** European FP7 project, FP7-REGPOT-2011-1, Project No.: 285939; 10/2011-09/2014. Coordinator: Prof. Ivan Petrović; http://across.fer.unizg.hr.
2. *DYMASOS – Dynamic Management of Physically Coupled Systems of Systems*, European FP7 project, FP7-ICT-2013-10, Project No. 611281; 10/2013-09/2016. Head of the Croatian team: Assoc. Prof. Mato Baotić; http://cordis.europa.eu/projects/rcn/110001_en.html

3. *ASSISI – Animal and robot Societies Self-organise and Integrate by Social Interaction*, European FP7 ICT project, Project No. 601074, 02/2013-01/2018. Head of the Croatian team: Prof. Stjepan Bogdan; http://assisi-project.eu/
4. *EC-SAFEMOBIL – Estimation and Control for Safe Wireless High Mobility Cooperative Industrial Systems*, European FP7 IP Project, 07/2011-07/2015. Head of the Croatian team: Prof. Zdenko Kovačić; http://www.ec-safemobil-project.eu/
5. *OpenIoT – Open Source Solution for the Internet of Things into the Cloud*, European FP7 project, ICT-2011.1.3, Project No. 287305; 2013-2014. Head of the Croatian team: Assoc. Prof. Ivana Podnar-Žarko; http://openiot.eu
6. *UrbanWater - Intelligent Urban Water Management System*, European FP7 STREP project, FP7-ICT-2011.6.3., Project No.: 318602; 12/2012-05/2015. Head of the Croatian team: Asst. Prof. Mario Vašak; http://urbanwater-ict.eu/

5.4 Contribution to economic and societal development of Croatia and technology transfer

ACROSS will have a strong impact on Croatian economic and social development by offering information and services, based on ACROSS's upgraded RTD capacity and capability, to general public and all the interested stakeholders (scientific community, students, large industry and SMEs, end-user community, governmental bodies).

Contribution to Croatian science and higher education

ACROSS is strongly founded on the research strategies of the host institution (FER)[64], addressing directly six (6) out of seven FER's (7) strategic thematic areas (safe, clean and efficient energy; smart integrated transportation, adapted to environment; inclusive, innovative and safe society; networks and services of the next generation; industrial and service economy; health; advanced materials) in a truly inter-disciplinary setting. ACROSS will lead to scientific renewal, and play an important role in defining and developing future direction for research related to cooperative systems and their applications. The most direct contribution of the ACROSS Centre to the development of Croatian science will be highly-specialized training of young researchers engaged in research projects of the Centre. ACROSS will educate between 80 and 100 doctoral candidates and provide postdoctoral training for more than 20 candidates within its four strategic research domains. The research results will also strongly contribute to the continuous improvement of existing MSc and PhD programs at involved institutions, and a new international Master-level program will be promoted by ACROSS.

Contribution to Croatian economy

Research results accomplished within the ACROSS Centre have been proactively disseminated to industry by several means: i) periodic industry-related events; i) research-driven clusters; iii) trade fairs, etc. We expect that some of our research results will be implemented in new innovative products and services, either in collaboration with existing companies or through spin-off companies started by some of the recruited researches in the Centre. In order to strongly support transfer of knowledge to industry, we will consider a possibility to engage a partner institution experienced in technology transfer and research

[64] http://www.fer.unizg.hr/en/strategy

results commercialisation to analyse the commercialisation potential, and devise the investment and market strategy for the ACROSS Centre in Croatia. The analysis of commercialisation potential includes market analysis, in particularly of potentially interested parties, the definition of criteria (and variables) needed for market segmentation, the profit potential and the development of target markets strategy. The target market strategy will be developed in three phases: (i) analysing market demand, (ii) targeting the market(s), and (iii) developing the market strategy. Based on the analysis, consumer demand will be defined as homogenous, clustered or diffused. Investment strategy will define possible sources of funding (domestic and foreign) and necessary steps to access them. Identification of costs and benefits will be included in cost effectiveness analysis and serve as a starting point to determine the range of financial and economic impacts of the Centre, depending on the commercialisation potential and considering intellectual property issues. To conclude, large industrial companies, SMEs, and spin-off companies will have the possibility to launch new products/services with the help of ACROSS. Also, the end-user community will have the possibility to use ACROSS expertise and developed solutions for their applications.

Contribution to Croatian society

Croatian society is faced with several major challenges: (i) to maintain or improve the current level of economic development with foreseen reduced workforce, (ii) to maintain a reasonable quality of life for increased number of elderly and handicapped people, (iii) to protect environment and ensure safety and security of people and goods, (iv) to improve quality of services and save energy in cities, etc. To tackle these challenges, there is a need for technology enablers of new services and for more efficient production methods. ACROSS aims to develop advanced cooperative systems which could significantly contribute to these challenges. Furthermore, Governmental bodies will have the possibility to use our expertise to improve legislative solutions and to prepare for the technology platforms relating to application areas in Croatia. Finally, it should also be emphasized that ACROSS will contribute to reversing the human capital flight, i.e. the “brain drain”, of Croatian scientists. It recruited returning Croatian researchers and, through its promotion and sustainability activities, act as a bright beacon attracting talented Croatian researchers.

5.5 Long-term substantiality of the ACROSS Centre

All three application-oriented ACROSS research domains − cognitive and robotic systems, networked and embedded systems and renewable energy systems – are high on EU research agenda up to 2020 and beyond (see chapter 1.2 Technology platforms - research and development agenda). The cooperation of heterogeneous systems in each of these domains is one of the most challenging and important research topics, as many new applications will be possible only by implementing advanced cooperative systems. Focusing its research activities on fundamental enabling technologies for future implementation and application of advanced cooperative systems, and building upon its high level of research team expertise and achievement so far, ACROSS Centre aims to become a regional leader and also a recognised EU (and world) research entity in these fields. Since the full implementation of the ACROSS Research Strategy requires more than a decade of intensive research, we will implement various measures for long-term sustainability and growth of the Centre. These measures will be implemented in close cooperation with national stakeholders and in synergistic use of EU Cohesion funds and EU Research and Innovation funds.

Sustainability measures implemented in close cooperation with national stakeholders

ACROSS Team members have a long-lasting collaboration with Croatian industry, both through joint R&D projects with companies and through joint RTD proposals in response to open calls by research funding agencies. Most of our research projects have been funded by the Ministry of Science, Education and Sports (MSES), Croatian Science Foundation (HRZZ) and The Business Innovation Croatian Agency (BICRO) (see chapter 4.3 Public funding). Based on gained experience, we will explore the measures for sustainability which include: (i) establishment of a research-driven clusters with industrial partners, predominantly SMEs, by the help of BICRO's funding program TEHCRO, (ii) boosting the cooperation with the industry by exploiting BICRO's funding program IRCRO, (iii) funding spin-off companies by researchers involved in ACROSS by the help of BICRO's funding programme RAZUM, and (iv) helping the leading young researchers to set up their research at academia or in industry via the funding programmes "HRZZ Installation Grants" implemented through The Croatian Science Foundation.

Sustainability measures implemented using EU Cohesion and EU Research and Innovation funds

The Structural Funds (SFs) and the Framework Programme (FP) are important instruments of the EU Cohesion policy and EU Research and Innovation policy 2014-2020, respectively (see chapter 4.5 EU funding). By working together, SFs and the FP can help mobilise RTD potential and contribute to regional economic and societal development much more effectively than if they were employed separately. ACROSS Team members have been very successful in applying for FP7 research funding – currently we are coordinators of 2 FP7 projects and partners in 5 FP7 projects, with total budget (our share) of more than 5 million Euro). We have also been successful in the EU pre-accession assistance programme (IPA program, which is similar to SF but intended for EU Candidate Countries) – currently we are coordinators of 2 IPA projects and partners in 3 IPA projects, with total budget (our share) of more than 1.5 million Euro). Based on gained experience, we will explore the measures for sustainability which include: (i) increasing the level of participation in EU Horizon 2020 projects, by networking with the leading EU research centres (particularly with 16 ACROSS collaborators) and the industry and by further increasing the competences of the Centre in submitting proposals and managing the EU projects, (ii) boosting the Centre premises and research capacities by applying for SF projects.

Phasing-out strategy

In case we do not manage to get enough funding for Centre operation beyond the ACROSS project lifetime, ACROSS Centre may persist as an informal research centre providing an interdisciplinary arena and laboratory infrastructure for future collaboration and reversal of the "brain-drain". ACROSS focuses on training of new generation of scientists for the academia and industrial research centres who will secure dissemination and renewal of knowledge in institutions of their future employments. The research results will also strongly contribute to the continuous improvement of existing MSc and PhD programs, and a new international Master-level program at UNIZG-FER will be promoted by ACROSS.