

EXPERT WORKSHOP REPORT ON ROBOTICS

Realized within the framework of
the project “3DCentral –
Catalyzing Smart Engineering and
Rapid Prototyping”

ABSTRACT

This report presents an expert knowledge on robotics in the region of Malopolska. This knowledge was acquired during the workshop held in the Krakow Technology Park on the 12th of April 2017.

Contents

| | |
|--|----|
| Introduction..... | 3 |
| Main findings..... | 4 |
| I. Developmental goals of the UE vis-à-vis development of robotics | 7 |
| II. Financial assistance for robotics and access barriers..... | 10 |
| III. Important regional projects and activities | 13 |
| IV. SWOT Analysis for Malopolska in the context of robotics..... | 22 |
| VI. Definition and key topics..... | 30 |
| Appendix 1. The Workshop’s Agenda | 32 |

List of Tables

| | |
|--|----|
| Table 1. List of experts participating in the workshop | 3 |
| Table 2. Barriers for accessing public funds | 10 |
| Table 3. SWOT Analysis of Malopolska Region in the Context of Robotics..... | 22 |
| Table 4. Ideas for initiatives supporting the growth of robotics in Malopolska | 28 |

Introduction

In this report we present the outcomes of the expert workshop held on the 12th of April 2017 in Krakow Technology Park. The aim of this workshop was to acquire expert knowledge on the current state and characteristics of robotics in the region of Malopolska. The workshop was run according to the agenda presented in the Appendix 1 to this report. What is important to state here, is that the Agenda was designed in the way to enable the participants to share their opinions on the following:

- I. Developmental goals of the UE vis-à-vis development of robotics
- II. Financial assistance for robotics and access barriers
- III. Important regional projects and activities
- IV. SWOT Analysis for Malopolska in the context of Robotics
- V. Recommended activities for the future growth of Robotics
- VI. Definition and key topics for Malopolska

Before presenting the outcomes it is worthwhile to mention that the experts who took part in the workshop represented private companies, universities, as well as regional administration. Their details are presented in the Table below.

Table 1. List of experts participating in the workshop

| <i>Name</i> | <i>Institution</i> |
|---------------------------|--|
| Dr inż. Stanisław Krenich | Cracow's University for Technology |
| Paweł Handzlik | ASTOR (SME) |
| Krzysztof Kubicki | EC Engineering (large enterprise) |
| Dominik Nowak | Husarion (start-up) |
| Agnieszka Górniak | Marshal Office of the Malopolska Region – Department for Regional Policies |
| Jakub Stec | ABB (large enterprise) |
| Tomasz Kwiatkowski | Marshal Office of the Malopolska Region – Department of Regional Development |

Main findings

I. Developmental goals of the UE vis-à-vis development of robotics

Experts identified the following main EU policies and activities that could influence the growth of robotics:

1. All policies and activities supporting the growth of entrepreneurship – Entrepreneurship 2020 Action Plan is especially worth mentioning. Also, all specific actions that target support of SMEs in general as well as their digitalization. Moreover, all actions targeting the development of IT sector.
2. Actions that fall under Digital Single Market Agenda. Especially initiatives that aim at the development of data economy.
3. All initiatives that address the problem of aging societies. Especially activities related to the support of so-called silver economy and growing demand for such services as home care, rehabilitation, or other health services that may be carried out by robots.
4. Actions implementing Horizon 2020 and all other activities aiming at strengthening research involving collaboration between academia and business.
5. Development of universal NGA internet access.

II. Financial assistance for robotics and access barriers

Three main access barriers to national and European funds supporting R&D are:

1. Little specific knowledge about the characterization of support programs on the side of potential beneficiaries. One can also add, that the knowledge itself is dispersed which makes the process of learning about the programs' specificities even more difficult.
2. Low flexibility of the projects funded (or co-funded) with public resources – understood as the necessity of keeping in place the initial assumptions of the projects, although the situation (be it market, scientific or otherwise) has changed dramatically in the course of the project's realization.
3. Fear of bureaucracy and lack of trust towards public administration. Companies fear they will not be able to manage procedures properly. They also do not trust that public administration will be able to assist them in good faith in case problematic situations occur.

III. Important regional projects and activities

Experts indicated 15 initiatives important for robotics in the region of Malopolska. As the most interesting ones (addressing important issues and involving many partners) one could see:

1. ASTOR Innovation Room – a laboratory space created by company ASTOR in the Cracow's Center where one can test the application of robots. Workshops and other educational activities for young people are organized there. It also serves as a presentational platform and show-room for promotional purposes.

2. A project that aims at the construction of fully autonomous underwater robot that is undetectable by radars. This project has two sub-projects – one of them is currently co-financed by Polish Ministry of Defense and the other by German Army. The robot is to be not larger than one meter long and that could go up to 20 meters deep. The Cracow's University of Technology is responsible for the creation of mechanical construction of the robot. Two patents are already pending in relation to R&D carried out within this project.

3. Husarion – A company which is developing a system for fast prototyping of robots. It concentrates mainly on the software and technical aspects. They provide ready-to-go software modules and cloud solutions which enable fast iterations in the development of specific software for a given robot. Usage of their solution substantially lowers the costs of prototyping and, thus, the costs of market entry for innovative solutions – especially in the area of consumer and service robotics.

IV. SWOT Analysis for Malopolska in the context of Robotics

1. Main regional strengths mentioned by the experts were: (a) the presence of many universities, faculties, and study programs in the area of robotics and related domains (as, for instance, IT); (b) high quantity and quality of human skills, talents and human capital in virtually all domains related to robotics.

2. As main weakness, the experts indicated a very low presence of manufacturing industry in Malopolska. Especially the lack of automotive industry which is seen as a catalyst for the development of robotics.

3. Opportunities lie mainly in the dynamic development of domains such as service and consumer robotics (also the military application of robots). These markets are still in their early stages of development which means that the costs of entry are relatively low while acquiring competitive advantage relies mostly on creativity and IT competencies.

4. Main threats come from the strong, international companies that are involved in industrial robotics and solutions for mass production.

V. Recommended activities for the future growth of Robotics

The experts shared 11 ideas for initiatives with a potential to boost the development of robotics in Malopolska. The ones that inspired most interest and enthusiasm were:

1. The creation of educational and exhibition center for robotics that could present the most recent and most spectacular achievements; and would also run educational activities for various target groups.

2. Support for SMEs in reaching international markets.

3. Smaller initiatives targeted at students (competitions, hackathons) that would allow them to face real-world problems.

4. The organization of such a conference for robotics industry that would not be treated by companies as an opportunity to sell their products, but rather as a platform to discuss important issues – like the

directions in which robotics should develop for instance.

VI. Definition and key topics for Malopolska

1. Experts proposed the following definition of robotics: *“As robots one can understand autonomous, programmable, multipurpose machines that support manipulative, technological and logistical processes, as well as services. Robotics, as a domain of scientific and business activity supports the development and distribution of such machines to their end-users (institutions, enterprises or individual customers). Robotics was traditionally seen as mainly domain of engineering related to algorithmics and automatization. However, currently – together with dynamic digitalization – one can point to stronger relations of robotics with such domains as informatics, artificial intelligence, nanotechnology, or bioengineering. Moreover, because robots are being applied in virtually all domains of human activity, the design and production of robots requires knowledge about other social, biological or physical processes. For instance, creating robots for healthcare requires knowledge on the medical practices and human biological processes; or creating machines for underwater operations require knowledge about physical forces caused by the movement of wind and water.”*

2. Sub-domains of robotics indicated by experts as important for Malopolska are: industrial robotics (especially applications for lower scale productions), military robotics, service and consumer robotics.



I. Developmental goals of the UE vis-à-vis development of robotics

In the first part of the workshop the experts were asked for a reflection on the European Union's development goals and their relation to the area of robotics. The experts were to share their opinions, indicating whether the development directions undertaken by the EU can aid in developing robotics as a field of human activity. Some of the questions the experts were searching the answers for, were, for instance, "which of the EU socio-economic developmental goals and which of the policies will support the development of robotics and which will impede its progress".

The most direct link to the European goals that was mentioned by the experts targeted all EU's actions related to the development of entrepreneurship. The experts – in their conversations – referred (although indirectly) to all layers of the "Entrepreneurship 2020 Action Plan". The Plan states that the EU will support the development of interventions aiming at: (1) entrepreneurial education, (2) diminishing administrative barriers and supporting entrepreneurs in all key phases of the business cycle, (3) stimulating the development of entrepreneurial culture.

The experts who took part in the workshop stated that actions undertaken in all of the three areas may – if calibrated properly – support the development of robotics. Specifically, this holds true when the IT sector is taken under consideration as robotics and automation relies more and more on software. Software production, on the other hand, relies less on huge capital investments but more on creativity; or creative capital. This seems to be an opportunity for a region like Malopolska which is being widely recognized for its substantial IT potential. Thus, development of entrepreneurship can happen through – for instance – educational programs for young engineers that would draw their attention to the possibilities that lie within the domain of robotics. This potential is identified not so much in the construction of industrial robots, but in the necessity of programming and reprogramming existing robots. Experts claimed that young talents could and should be inspired through particular examples or cases. It can be also worthwhile to add, that the IT potential may be used for the development of the sensor capabilities of the already existing robots.

It is also worthwhile to mention that achieving the Digital Single Market within the EU is an important goal for developing robotics. Thus, all the initiatives undertaken by the Commission within this context seem to be important. Removing international barriers within the EU can facilitate international partnerships within the robotics industry. Especially important are those EU's initiatives and goals that fall under the category "Digital as driver for growth". For, actions within this category are aimed at improving the development of the Data Economy. Free flow of data (and access to it) may influence sound decision-making, but also provide proper foundation for the knowledge economy (which robotics is part of). In effect, the design of robots may improve and they may become more adequate in matching both industry's and society's needs. Equal access to data, may also improve software development and scientific advances in the field of robotics.

During the workshop, experts also identified an important trend in robotics. Namely, development in healthcare and consumer robots – thus, machines that support humans in rehabilitation or care for senior citizens for instance. The development of these domains may be supported by all EU’s initiatives that aim at solving problems related to the aging of societies in general. For, it is clear that with demographical changes, the needs of senior citizens will become much more important in the economy. New intelligent machines may address many of these needs. This trend may be of special importance to Małopolska as the creation of such robots will rely much more in the construction of smart and intelligent software – and IT competencies are very much present in the region. Also directions such as mobile robots LGV, drones, autonomous vehicles or speech and image recognizing systems should be mentioned as important trends for the robotics in Małopolska – also for its reliance in informatics.

It is also worth adding that the above comments from experts suggest that reaching the objectives set by the SPARC Strategic Partnership will be extremely important for the growth of robotics. Experts who took part in the workshop indirectly pointed out that important - from their perspective - will be advances in a domain such as Consumer Robots with the special meaning of sub-domain "assisted living", which directly refers to the strengthening the independent life for people of all ages and regardless of their health situation. The progress achieved in supporting the development of the healthcare domain, which is closely related to the assisted living sub-domain, will also be important; which is about the development of robots used in close association with the provision of health services by the relevant institutions.

A European contribution to the development of R&D will also be of key importance to supporting robotics’ growth. This is directly linked to the objective of supporting smart growth and knowledge economy as defined in the Europe 2020 Strategy. In this context, reaching a state in which 3% of EU’s GDP is being spent on R&D is also of crucial importance. Actions to support this goal can strengthen the development of robotics, as it is a sector that is heavily dependent on the ability to implement R&D. In addition to the obvious financial support for research activities, it is necessary – as the experts claim – to support all possible collaborations between the scientific world and the world of business. It is possible to use a variety of funds that support R&D partnerships to reach the research objectives of specific companies. Experts almost unanimously stated that European instruments to finance R&D by companies or by consortia created in partnerships with universities are important for local robotics development. At the same time, it is important to know that the awareness of the existence of such opportunities and their specific characteristics in local communities is low. In addition, experts have wondered if the instruments of this type may have a negative impact. For example, the company may engage in a project that is not thoroughly thought out from business side just because the opportunity to raise funds exists.

Experts also stated, that it is of a special importance to support the Small and Medium Enterprises (or SMEs) – for, on the one hand, they may become beneficiaries of European Funds, creating

partnerships with Universities to create innovative solutions in robotics. On the other hand SMEs may be interested in purchasing solutions created in such way. According to experts, it is not true that solely big manufacturing companies may utilize robotization in a meaningful way. However, many SMEs do not realize the potential that lies in robotics. Thus, a proper educational initiatives are needed which – in the eyes of the experts – would also support the development of entrepreneurship as such.

Supporting smart growth (identified as one of the objectives of Europe's 2020 strategy) also means supporting the development of digital society. Experts that took part in the workshop underlined the importance of educational initiatives aimed at the development of public consciousness about robotics and at overcoming fears. Also, increasing competencies that would allow the public to make proper use of robotics applications will support creating a demand for such products. What is more, increased knowledge and competencies may create a positive consumer pressure leading to even more innovations in the field of Consumer Robotics. Those will influence the quality of life positively.

It is also worth adding that one of the barriers to building greater digital competencies (including robotic skills) on the side of the public, is the lack of general access to very fast internet connections. In this context, it is extremely important to achieve the infrastructure objective of providing NGA access to 100% of EU households; with particular emphasis on the availability of high-speed internet in schools. The European Commission has set a deadline for achieving this objective by the year 2023. In Poland, the effectiveness of the implementation of the Operational Program Digital Poland (implemented mainly from EU funds) will be significant here – its 1st Axis aims at the development of full NGA network coverage.

Based on experts' statements and opinions, one can draw conclusions about the milestones which – when reached – will also boost robotics:

1. Launching and effective implementation of programs supporting partnerships between the world of science and the robotics industry
2. Significant increase in the number of robotics researchers
3. Launching of programs supporting the development of laboratory infrastructure at universities
4. Carrying out large-scale education and informational campaigns targeting both the public and the SMEs sector.
5. Provide access to NGA networks and digital literacy programs for all members of the society
6. Conducting campaigns to promote robotics in domains such as Consumer Robotics, Healthcare robotics, or "assisted living" robotics.
7. Achieving a state where 3% of GDP is spent on R&D, a majority of which is spent by the private sector.

II. Financial assistance for robotics and access barriers

In the second part of the workshop the experts listened to Mrs. Agnieszka Górnica's presentation on the current possibilities for raising funds for robotics' research and development. Subsequently, participants were asked to clarify what barriers exist in the Malopolska region regarding the access to these resources. Below, we present, a list of the main barriers identified by experts along with a brief explanation of each of them.

Table 2. Barriers for accessing public funds

| No. | Title | Explanation |
|-----|---|--|
| 1 | Little knowledge of the specificities of individual calls on side of potential beneficiaries | As experts explained, there is a lot of financial support for R&D projects in the field of robotics. However, each of these public programs has a rather complicated structure and rules. It is, thus, important to invest a significant amount of time in getting to know the whole support structure in order to identify the right program for one's specific needs. Time is a specific resource that not everyone can devote while more pressing issues related to current professional obligations are at hand. It can also be mentioned that the knowledge of grant possibilities is highly dispersed, which makes it even more difficult to find the adequate program |
| 2 | Fear of bureaucracy | Many companies are afraid of the complexity of administrative procedures. Public funds are made accessible under a specific administrative regime, which is not well known to private companies. Hence, they are concerned about the administrative complexity, but also about the lack of flexibility with regard to the necessary procedures. Many companies find it safer not to enter into such a relationship with public administration. |

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|---|---|--|
| 3 | Low flexibility of projects | Companies also fear that the logic of multi-year projects is too rigid. They are afraid of a possibility of a situation in which a given company arrives at the understanding that project is no longer viable business-wise; after having completed only 2 of 5 years (for instance). Companies fear that in such situation they will be required to complete the project irrespective of its business justification – with the sole purpose of not losing already invested financial resources. Therefore, companies prefer to use more flexible forms of financial support. Or not to take risk whatsoever. |
| 4 | Fear of losing control over the idea | Many support programs require collaboration with other partners. Companies fear that, even in its early stages, such cooperation will reveal potential business ideas or even corporate secrets. |
| 5 | Patent difficulties | It is often the case that, in the course of conducting research and development, it turns out that the solution the researchers are working on has been already patented. In such a situation, it is impossible to meet the targets of the project. In the case of a free market company, it is possible to buy a license or the patent itself, but this may not always be possible, or it may override the business rationality of the venture. Companies fear that in such situation they will face the necessity of not completing the project and not being able to qualify for the costs already incurred. It is worth adding that very often it is not possible, for practical reasons, to identify all patents existing in the project area at the start of the project. In addition, some patents may be submitted by third parties once the project has already commenced. This is a particular risk that companies are afraid of when reaching for public support. |
| 6 | Short time horizon of planning in Polish companies | Many Polish companies operate according to low cost logic. This means that their key competitive advantages depend on economies of scale and the marginal cost of producing a given good. In such business logic, companies focus on maximizing sales of goods or services rather than maximizing profit margins through innovation. Management does not take into account the long time horizon and it is difficult for them to undertake R&D initiatives lasting for years and characterized with high risk of failure. |

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| 7 | Difficulties in applying for funds | Experts identify that the process of acquiring funds is difficult and time consuming. Often one needs to seek support of companies specializing in acquiring the funds. The process itself is often incomprehensible and therefore many companies do not decide to enter the procedures because of the level of perceived complexity. |
| 8 | Necessity of one's own contribution | Many grant projects require one's own financial contribution. This is a challenge for companies, but they are able to invest their own capital (though this is perceived as a barrier). However, in the case of universities, this is often a deal-breaker. |
| 9 | Lack of companies' faith that the support is real | Experts pointed out that in many cases companies still do not believe that public support is provided in good faith. One can point to an existence of lack of trust and constant dislike for dealings with public administration. Hence, many actors do not even consider that the public administration can support their activities in any way. |
| 10 | High costs | Many robotics projects require high capital costs. This is especially the case in industrial robotics. |
| 11 | Ethical and legal issues | <p>Along with the automation and robotization of certain processes, ethical challenges arise. For example, a situation where the robotization of a given factory results in the loss of jobs for many people seems ethically problematic. In addition, robots - because of their digital nature and internet connectivity - collect information about their users. It is not clearly regulated how these data can then be used by companies. More and more doubts arise in this area, which will require new legal solutions. The barrier in this context is an uncertainty over what is allowed.</p> <p>It is important to add, that although the above barrier was mentioned by some experts, one participant strongly opposed this point of view. To his knowledge, current examples of robotization show that even more jobs are created when machines are used for operations. The expert also mentioned that data gathered by robots are much less ethically problematic than the data gathered by smartphones and their applications.</p> |

III. Important regional projects and activities

During the following part of the workshop the experts were asked to share their knowledge about interesting activities and initiatives happening in the region and connected to robotics. The experts named 15 of such activities in total – we present them below.

| | | | |
|--|--|--|------------------|
| Activity title | | | |
| Research on improving functionality of industrial robots | | | |
| Activity description | | | |
| A research project realized in partnership between company ASTOR and Cracow's University of Technology. Its aim is to introduce new monitoring devices and to use them in order to improve robots' accuracy. | | | |
| Source of finances | The National Center for Research and Development | Amount of finances | 1 200 000 PLN |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Cracow's University of Technology | Ksenia Ostrowska | kostrowska@mech.pk.edu.pl | +48 512 093 608 |

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|--|---------|---------------------------|-----|
| Activity title | | | |
| FlyTech UAV | | | |
| Activity description | | | |
| A Cracow based company which develops drone solutions and implements them for clients from different sectors. They are experts in programming drones. They are also familiar with all legal regulations concerning drones and air traffic. | | | |
| Source of finances | Private | Amount of finances | N/A |

| Activity's Leader | | | |
|--------------------------|-----------------------|--|------------------|
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| FlyTech UAV | Michał Wojas | mwojas@flytechuav.com | +48 514 446 933 |

| Activity title | | | |
|---|-----------------------------|--|------------------|
| Husarion | | | |
| Activity description | | | |
| <p>A company which is developing a system for fast prototyping of robots. It concentrates mainly on the software and technical aspects. They provide ready-to-go software modules, cloud solutions which enable fast iterations in development of specific software for a given robot.</p> <p>The system is also made available to students. And the company would like to promote its use among research institutions.</p> | | | |
| Source of finances | Own funds, VC, crowdfunding | Amount of finances | N/A |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Husarion | Dominik Nowak | Dominik.nowak@husarion.com | +48 796 278 877 |

| | | | |
|--|-----------------------|--|------------------|
| Activity title | | | |
| Astor Innovation Room | | | |
| Activity description | | | |
| A laboratory space created by company ASTOR in the Cracow's Center. Workshops and other educational activities for young people are organized there. It also serves as a presentational platform and show room for promotional purposes. | | | |
| Source of finances | Private | Amount of finances | 1 500 000 PLN |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| ASTOR | Paweł Handzlik | pawel.handzlik@astor.com.pl | +48 12 424 00 68 |

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|--|-------------------------------------|--|------------------|
| Activity title | | | |
| Sorter | | | |
| Activity description | | | |
| A company based in Radom that produces robotic solutions for gardens and fruit farms. It is well known for its apple sorting device. It is also involved in R&D projects funded by EU which would aid the company in creating their own robots. Currently the company utilizes components produced mainly in Poland. | | | |
| Source of finances | Private/EU | Amount of finances | N/A |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Sorter sp. jawna Konrad Grzeszczyk Michał Ziomek | Konrad Grzeszczyk, Michał Ziomek | biuro@sorter.pl | +48 48 377 99 99 |

| Activity title | | | |
|--|-----------------------|--|------------------|
| Center for creating applications for packaging and palletization | | | |
| Activity description | | | |
| Created in 2009 in Warsaw by ABB – it begins to be internationally recognized. Its aim is to create ready-to-go machines based on other ABB's products. Center has an opportunity to enter global value-chain. | | | |
| Source of finances | Private | Amount of finances | N/A |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| ABB | Jakub Stec | Jakub.stec@pl.abb.com | +48 695 420 139 |

| Activity title | | | |
|---|---|--|------------------|
| Industrial robotics' application | | | |
| Activity description | | | |
| An EU co-funded project done with participation of ASTOR with one of the regional manufacturers. Its aim was to create three fully automated welding posts. | | | |
| Source of finances | EU – through Operational Program Innovative Economy | Amount of finances | 15 mln PLN |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Astor | Paweł Handzlik | pawel.handzlik@astor.com.pl | +48 12 424 00 68 |

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| Activity title | | | |
| FISH #1: Autonomous underwater vehicles | | | |
| Activity description | | | |
| A project that aims at the construction of fully autonomous underwater robot that is undetectable by radars. This project is currently co-financed by Polish Defense Ministry. The robot is to be not larger than one meter long and that could go up to 20 meters deep. Cracow's University of Technology is responsible for creation of mechanical construction of the robot. | | | |
| Source of finances | Polish Ministry of National Defence, The National Center for Research and Development | Amount of finances | 3 816 000 PLN |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Cracow's University of Technology | Prof. Jerzy Zajac | zajac@mech.pk.edu.pl | +48 12 374 32 43 |

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| Activity title | | | |
| FISH #2: Swarm of Biomimetic Underwater Vehicles for Underwater ISR (SABUVIS) | | | |
| Activity description | | | |
| The projects has very similar aims to the one described above. However this version of it is co-run with German Army. | | | |
| Source of finances | European Defense Agency | Amount of finances | 1 456 259 EUR |

| Activity's Leader | | | |
|-----------------------------------|-----------------------|--|------------------|
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Cracow's University of Technology | Prof. Jerzy Zając | zajac@mech.pk.edu.pl | +48 12 374 32 43 |

| Activity title | | | |
|---|-----------------------|--|------------------|
| Ithaca | | | |
| Activity description | | | |
| Project aims at the collection of good practices in the realm of ageing – solutions like telemedicine are being examined. It is an Interreg project that involves c.a. 10 EU partners like hospitals, clinics, scientific institutions. | | | |
| Source of finances | EU/ Interreg | Amount of finances | 2 263 144 EUR |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Marshal Office of the Malopolska Region | Magdalena Klimczyk | magdalena.klimczyk@umwm.pl | +48 12 29 90 923 |

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|--|------------------------------------|--|------------------|
| Activity title | | | |
| Malopolska Laboratory of Low Energy Constructions | | | |
| Activity description | | | |
| A building equipped in hundreds of sensors that are used for monitoring and evaluation of how energy is being used in households. It is the only lab of such type in CEE region. The building is inhabited by a robot called Alex which is to resemble the human activity inside the building. The lab serves as means to develop solutions for the construction of passive buildings. | | | |
| Source of finances | N/A | Amount of finances | N/A |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Cracow's University of Technology | dr inż. Małgorzata Fedorczyk-Cisak | biuro@mcbe.pl | +48 12 628 31 23 |

| | | | |
|--|-----------------------|---------------------------|------------------|
| Activity title | | | |
| Robots for mining | | | |
| Activity description | | | |
| A collaboration between Cracow's University for Science and Technology and partners from Sweden, Germany and Spain. The partnership aims at the discovery for new robotic solution to be applied at any stage of mining. | | | |
| Source of finances | N/A | Amount of finances | N/A |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| N/A | N/A | N/A | N/A |

| | | | |
|--|-----------------------|--|------------------|
| Activity title | | | |
| Robocomp | | | |
| Activity description | | | |
| Competition of robots organized by a student society of Cracow's University for Science and Technology | | | |
| Source of finances | N/A | Amount of finances | N/A |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Integra society www.integra.agh.edu.pl/ | N/A | kontakt@robocomp.info | N/A |

| | | | |
|---|-----------------------|--|------------------|
| Activity title | | | |
| Series of discussion panels on robotics organized by Magazyn Przemysłowy (Polish monthly devoted to the topic of manufacturing and economy) | | | |
| Activity description | | | |
| Panels are being organized during conferences and meetings and are devoted to such topics as internet of things and/or robotics. | | | |
| Source of finances | N/A | Amount of finances | N/A |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| Magazyn Przemysłowy MM | Paweł Kruk | Pawel.kruk@magazynprzemyslowy.pl | 71 78 23 195 |

| | | | |
|---|-----------------------|--|------------------|
| Activity title | | | |
| Contest for best student dissertations in the topic of robotics | | | |
| Activity description | | | |
| Organized by ASTOR for the Polish students | | | |
| Source of finances | Private | Amount of finances | 25 000 PLN/year |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| ASTOR | Paweł Handzlik | Pawel.handzlik@astor.com.pl | +48 12 424 00 68 |

| | | | |
|---|---|--|------------------|
| Activity title | | | |
| Educational post | | | |
| Activity description | | | |
| An educational post implemented on one of the universities in Cracow by company Astor | | | |
| Source of finances | EU – through National Cohesion Strategy | Amount of finances | 150 000 PLN |
| Activity's Leader | | | |
| <i>Organization</i> | <i>Contact person</i> | <i>e-mail</i> | <i>Phone no.</i> |
| ASTOR | Paweł Handzlik | Pawel.handzlik@astor.com.pl | +48 12 424 00 68 |

IV. SWOT Analysis for Malopolska in the context of robotics

The following part of the workshop was devoted to conduct – with the help of the experts – SWOT analysis for Malopolska in the context of robotics. Before presenting the results of this analysis it is important to remind that SWOT is one of the most fundamental tools of strategic analysis. It allows for organization of the information according to their classification as Strength, Weakness, Opportunity or Threat. It can be performed to analyze the situation of a given company, narrow aspects of its operations or – on the contrary – for the analysis of a broader economic phenomena.

Strengths refer to all positive inner aspects of the analyzed phenomenon. Aspects that can also be equated with competitive advantages. Weaknesses refer to those inner aspects that may constraint the development of the analyzed phenomenon. While Opportunities and Threats refer to the outside forces that remain out of direct control.

Below, we present the outcomes of the SWOT analysis performed with the experts during the workshop.

Table 3. SWOT Analysis of Malopolska Region in the Context of Robotics

| <u>Strengths</u> | <u>Weaknesses</u> |
|---|--|
| <ul style="list-style-type: none"> - high number of technical universities and high number of graduates; - high number of robotics related majors and study programs <ul style="list-style-type: none"> - strong IT potential; - flexibility of employees and graduates; - the existence of industrial design study program at the Faculty of Industrial Forms of the Academy of Fine Arts; - presence of large companies cooperating with universities; - qualified personnel prepared to build robotic systems and solutions; | <ul style="list-style-type: none"> - lack of large industry; - lack of robotic companies; - lack of Polish large integrator companies; - lack of decision-making capabilities in Polish factories that are part of global corporations; - insufficient number of jobs for graduates; - few companies producing high quality robot components (engines, control circuits); - high salaries in IT may cause brain drain from robotics to IT; - few good terrains for large industry (land fragmentation); - lack of local automotive companies; <ul style="list-style-type: none"> - education does not meet industries' requirements fully; - insufficient number of partnerships in education; |

| Opportunities | Threats |
|--|---|
| <ul style="list-style-type: none"> - the strength of Polish integrator companies is growing; - decision-making in factories is shifting; - more Polish managers working in foreign headquarters; - growing experience of Polish companies; <ul style="list-style-type: none"> - low unemployment in Malopolska; - cheaper technology; - Brexit - moving companies from England to other EU countries; - A4 motorway - access to customers in the west, access to terrains proper for factories and plants; - development of service robots (robotics service); <ul style="list-style-type: none"> - development of military robots; - robotic applications; - access to external financing; - proximity of Silesia (access to engineers, automotive companies and other customers) - proximity of the Podkarpackie region (air valley) | <ul style="list-style-type: none"> - strong competition of integrator companies from Western Europe; - large players force co-operation with specific foreign companies; <ul style="list-style-type: none"> - Brexit – constrained access to British automotive industry; - saturated market of industrial robot companies; - high dynamics of changes in the technology and economics; - high dynamics of knowledge change; |

Strengths

All participants agreed that the number of technical universities in the region should be seen as a strength. Because of that, a large number of highly skilled graduates enter the labor market (about 500 graduates each year). It was emphasized that there are many fields of study which can contribute to the strong development of robotics in the region e.g. robotics, automation, mechatronics, computer science. In addition, the high quality of education at these institutions was emphasized. Experts also pointed to the fact that, due to the large number of applicants who apply for these universities, only the most capable persons are admitted. In this context, it is worth adding that robotics and computer science at AGH (University of Science and Technology) require highest educational scores if one wants to be admitted; which additionally influences the positive selection of people for such studies. Experts emphasized that human potential - talent - in Malopolska is very high.

The offer of studies related to robotics in Malopolska is substantial, which translates into higher interest in this subject both among current students and those planning to complete a college degree. One can specifically name three key universities that deal with robotics and closely related topics:

1. AGH – University of Science and Technology. Especially The Faculty of Electrical Engineering, Automation, Computer Science and Biomedical Engineering, which is one of the biggest faculties of all Polish universities; also Faculty of Mechanical Engineering and Robotics, which is one of the oldest and largest AGH faculties.
2. The Cracow University of Technology. One can name the Faculty of Mechanics, which offers, among others, studies in the field of Automation and Robotics.
3. Jagiellonian University. One can specify here the Faculty of Mathematics and Applied Computer Science, which runs studies in information technology.

Experts have also pointed out that the functioning of other higher education institutions can play an important role in the development of robotics (such as those that teach in the fields of design, for instance). It may be of value to mention that Krakow is one of the few cities in Poland where one can study industrial design at the Academy of Fine Arts. It was also mentioned that students of this major sometimes cooperate with students of technical universities creating IT projects. Such interdisciplinary cooperation in the field of high technology may give a good foundation for the future development of robotics. This may be especially important for the development of new robotics. For, solutions of this type must be created within a form that is both ergonomic and useful.

Another strength named by the experts is the presence of high quality IT talents in the region. This aspect seems to be important when one looks at robotics through the prism of web or mobile applications that serve for controlling the robots. It is very much connected to the potential the expert see in the development of new domains in robotics – not necessarily connected to the field of industrial robotics where one needs to invest a lot of capital to build heavy machines used for mass production.

Experts also pointed out that, unlike workers in Western countries, Polish companies show great flexibility. Employees are able to adapt to changing business conditions. One can also add that people graduating in automation and robotics adapt easily to mechanics or computer science. This aspect is perceived by experts as the strength of the region.

The cooperation between large companies and universities has also been recognized as a strength. Companies provide special equipment that can be used by students. Also, industry experts give university classes. Experts also noted that such cooperation should develop faster and generally should be further supported. But in many cases, it is already real and supports the robotic potential of the region.

Weaknesses

As one of the significant weaknesses that were pointed out firmly was a lack of large industry in Malopolska. It is a significant weakness, as a large industry is usually responsible for the demand for robots and stimulates the development of the robotics in general. This was considered – during the workshop – to be one of the key factors causing not many companies to produce their own robots in the region. One can speak of the presence of so-called "integrators" – firms that use the components of other companies to develop a specific application. The lack of a sufficient number of producer companies is also linked to the lack of a sufficient number of jobs related to robotics, which in turn often makes talented graduates often to change the industry or leave the region.

Another obstacle to the development of the robotics industry in Malopolska is the lack of big and strong local integrators with substantial experience – those which exist are rather small in size. The experience here has a crucial meaning – companies in search for robotization usually turn to integrators that can show a portfolio of successful applications. In effect, many companies need to seek the collaboration of the foreign firms who can execute better and cheaper, because of the know-how they possess.

One of the weaknesses is also the low number of Polish companies producing components of high quality for robotic solutions.

Strong IT sector can be also seen as a weakness. There is high demand for IT skills which translates into higher salaries than in the field of robotics. This may cause many graduates of robotics to change their expertise to IT as it is relatively easy for them do.

The experts also pointed to the fact that there is a lack of automotive industry in Malopolska. And it was said that car industry has been a strong stimulus for the development in robotics (for instance in Germany) – but also in high tech solutions connected to sensors.

It was also said that universities do not cooperate closely enough with the industry actors when it comes to the teaching curricula. The whole sector would benefit vastly if teaching programs were more in accordance with the industry's needs.

Opportunities

The low amount of jobs in "pure" robotics was named as a weakness of the region. However, some experts also pointed out that this can be seen as an opportunity. The lack of direct career opportunities for robotics' graduates may cause them to become more entrepreneurial and to create their own companies. They can – under the right conditions – start creating fast solutions on the

verge of service robotics and IT and acquire funds either through EU channels, or through private equity markets.

It was also said that many of the factories in Poland gain independence as to which subcontractor for robotization they may choose. Previously, very often, this decision was made outside Poland which caused that Polish companies were chosen very rarely. This approach is changing which one may see as an opportunity for Polish integrators. What is also important – Polish integrators begin to be well recognized also outside of Poland.

One of the experts, also pointed to the fact that some of the Polish managers are being moved to the headquarters of the big manufacturers. In effect, they start to influence important decision which may mean that Polish companies may be taken into consideration as contractors for implementing robotic solutions.

It is also important that in Malopolska the unemployment rates are very low. This puts a significant pressure on the companies to introduce robotic solutions. Very often, if one wants to grow, one needs to robotize its production.

The access to the EU and national funds for R&D is also seen as an important opportunity. These funds allow the introduction of innovative solutions, establishing new enterprises as well as development of new technologies.

Technologies, one the other hand, become cheaper very dynamically. This influences the cost of production of important components for robotics industry. This means that – in general – the cost of robotization is lower, which may influence demand in a positive way. Experts also pointed to the fact that Polish companies are cheaper than the foreign ones – even when the recent rise in Polish salaries is taken into account.

A4 highway was also mentioned as an important asset and an opportunity. It allows fast access to the foreign customers and, thus, can influence demand for the services of integrators and the producers of robots from the region. One can also mention that this highway lately reached the East of Poland which means easy access to the terrains allowing for the construction of manufacturing plants. This can influence the demand for robotics solutions even greater in the future if the proper investment occurs. A4 integrates such big cities as Rzeszów, Tarnów, Kraków, Katowice, and Wroclaw which also should be seen as an asset to any economic activity. Especially, good integration with the region of Śląsk is important here – as one can find automotive industry present there which is important for driving both demand and innovation in robotics. Also the region of Podkarpackie may be important as airplane industry is located there.

Many experts pointed out that the market for industrial robots is very much saturated and dominated by big international companies. For this reason the opportunities for actors from Malopolska lie mainly in the development of new Service Robots – applied in rehabilitation, logistics,

transport, etc. Also in Consumer Robotics. These markets are still in the early stages of development which increase chances for success for newcomers. Especially in the market for everyday-use robots the costs of entry are relatively low – particularly when compared to industrial robotics. One can also add that solutions for fast prototyping for these markets exist (like the ones of Husarion) which drive the costs of entry even further down.

Threats

A significant threat pointed out by the experts was the strong market position of foreign integrator companies – they are a very strong competition for companies from Malopolska. It is important to know the fact that most robotic solutions in Polish industry are carried out by foreign firms. This happens, as very often decisions are made outside Poland within the global headquarters of a given manufacturer.

“Brexit” could be seen both as an opportunity and as a threat. For in Great Britain the presence of automotive industry is strong and Brexit can cause the access to them (as potential customers) more difficult – more economic barriers may be introduced by the British government.

Mere dynamics in the technological and economic progress needs to be seen as a threat. As it is difficult to foresee what trend will dominate markets in 10 or 15 years time. Experts gave the examples of some American cities where automotive industry collapsed. This collapse meant substantial challenges for robotics as an industry because many companies were servicing the assembly lines in such factories.

One expert also pointed to the fact that the state of science and knowledge also changes very dynamically. Very often the information becomes obsolete which requires adaptation. One can also add, that very often the education system itself does not keep up to speed with the changes which may have negative consequences for the industry.

V. Recommended activities for the future growth of Robotics

During the workshop, the experts were asked to introduce ideas for specific initiatives that could be developed in order to promote the growth of robotics in the region. Each of the experts created and presented his/her own vision of such activities. Each of the experts also declared whether he/she would be interested in involving oneself in the implementation of such an activity in any manner.

This way, experts' ideas were probed for enthusiasm and viability. These ideas are presented below – however, it is important to know that some of them are just initial intuitions rather than complete visions of specific projects.

Table 4. Ideas for initiatives supporting the growth of robotics in Malopolska

| Idea | Description | Organizations declaring support in implementation * | | | | | |
|-----------------------|---|---|---|-----|----|----|----|
| | | ABB | A | Hus | UM | EC | PK |
| Information policy | The main goal is to develop and implement an information policy aimed at addressing fears public opinion may have in relation to robotics. Also to increase competencies of the public. One of the tools for implementing such policies could be events organized by Universities addressed to different target groups (eg children, students, adults, seniors). Interest in such events could also be used for the process of validating innovative products developed by local robotic companies. | | x | | x | | x |
| Investors acquisition | More activities of regional or city authorities, which would lead to greater industrial presence in Malopolska. Experts pointed out that one of the driving forces for robotics is the automotive industry, which does not exist in Malopolska. Appearance of such companies could be an opportunity for robotic companies. | | x | | | | |
| Robotics center | Creation of an exhibition and education center (similar to Copernicus Science Center), which would present the latest achievements in the field of robotics and, at the same time, organize educational workshops for different audiences. | | x | x | x | | x |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Department of robotics support (within structures of Krakow Technology Park) | Specialized administrative unit that would engage in many different activities supporting robotic branch in Malopolska. This include, among others, an incubator dedicated to robotics initiatives, as well as an investment fund that would invest in robotic ventures. | | x | x | | | x |
| Conference on the future of robotics and artificial intelligence | Organizing conference that will be detached from sales goals of robotics companies. Experts shared their opinions that there are many industry conferences, but during these conferences robotics companies only sell their products and services. There is no place for substantive reflection on, for example, direction of robotics development as such. | x | x | x | x | | |
| Robotic contests and hackathons | Smaller initiatives mainly for students. During such events they could face real problems related to robotics. Initiatives of this type exist, but there are not too many of them and they are not present in media. Additionally, it would be good if organizers of such events were independent from robotics companies. | x | x | x | | x | x |
| Support in internationalization | More active support for SMEs, which could allow them to enter the foreign markets. | x | x | x | x | | x |
| Social campaign | An information campaign aimed at breaking the fears of robots. | | x | | x | | |
| Developing laboratories at universities | Launching funds for universities to create laboratories with top equipment. It is also important that these finances should be relatively easy to obtain - for example, that they do not require the formation of complex partnerships. | | x | x | | | |
| Support for master's theses and engineering works created in collaboration with robotics industry | Tools which would significantly raise the number of master theses of this type. Experts pointed out that there are some existing barriers such as the fact that copyrights to these works always belong to the university. This limitation should be taken into account when developing such tools. | x | | x | | | x |

| | | | | | | | | |
|--|--|---|---|--|--|--|--|---|
| Training for SMEs of various industries on profits from robotization | These activities should be designed to create more demand for robotic solutions. They would break the stereotype that only large manufacturing companies can use robots. Trainings should demonstrate the potential of robotics for given industry and the benefits that robotic technology can bring even to small companies. | x | x | | | | | x |
| Interdisciplinary education | Enabling realization of robotics studies in a more interdisciplinary way than it is currently available. | | | | | | | |
| * PK – Cracow’s University for Technology, A – Astor, EC – EC Engineering, Hus – Husarion, UM – Marshal Office of the Malopolska Region, ABB - ABB | | | | | | | | |

VI. Definition and key topics

During the workshop the experts were also asked to discuss key areas of modern robotics that may be important for growth of robotics in the region. In this respect, the experts were eager to point to the fact that currently one can split robotics into two main fields – “old” robotics that refers to industrial robotics; and “new” robotics. The former refers to the construction of machines that are being used on the production lines in the process of production of a certain good; mass production but also production on lower scales. Companies that operate in this domain have long tradition and their market position is very firm. It is also worthwhile to mention that the market for such robots is global. Thus, the barriers of entry are relatively high while the competitive advantages that characterize “big players” are practically beyond reach of any newcomer. It was said, that this domain of robotics should not be of interest to companies from Malopolska.

The opportunities for local and relatively new companies lie mainly in the “new” domains of robotics. Experts described it also as “Service Robotics” which mainly refers to robots that can be used in healthcare and rehabilitation, assisted living, logistics, or for operations underwater (as for instance the project that is being developed by Cracow’s University of Technology). In all of the mentioned domains the markets are relatively in early stages of development. Experts claimed, that opportunities lie also in the fact that constructing the adequate software for such robots is of crucial importance – as Malopolska has a lot of IT potential. Thus, if the talents of regional programmers are drawn to these areas of robotics, one can hope for creation of new and innovative companies.

The experts were also asked to provide such definition of robotics that would encompass current state of the field as it is being understood by them. Basing on their insights, one can understand modern robotics in the following way:

As robots one can understand autonomous, programmable, multipurpose machines that support manipulative, technological and logistical processes, as well as services. Robotics, as a domain of scientific and business activity supports the development and distribution of such machines to their end-users (institutions, enterprises or individual customers). Robotics was traditionally seen as mainly domain of engineering related to algorithmics and automatization. However, currently – together with dynamic digitalization – one can point to stronger relations of robotics with such domains as informatics, artificial intelligence, nanotechnology, or bioengineering. Moreover, because robots are being applied in virtually all domains of human activity, the design and production of robots requires knowledge about other social, biological or physical processes. For instance, creating robots for healthcare requires knowledge on the medical practices and human biological processes; or creating machines for underwater operations require knowledge about physical forces caused by the movement of wind and water.

According to the experts one can divide robotics into four key sub-domains that have meaning for the region of Malopolska:

1. Industrial robotics – creating robots of the production of merchandise. One can add that robots have been traditionally used for mass production. However, currently robots are also used for lower scales of production. The abilities of robots in this domain are developing very fast and these developments are of higher importance for Malopolska. For, to use robots for lower scale production, one needs more of IT and programming skills than the ability to create heavy machines. And Malopolska is recognized for its strong IT potential. On the other hand, these low-scale solutions can also be implemented by regional SMEs.

2. Military robotics – solutions created to support soldiers on the battlefield or to substitute them. In the former respect one can mean machines responsible for carrying heavy equipment, but also robots responsible for gathering intelligence or for minor operational actions. One can also include here underwater solutions used for military purposes – a project of this type is being developed in Malopolska currently.

3. Service Robotics – this field is about creating solutions for health-care, agriculture, inspection of objects, cleaning, transport and logistics, etc. It is about performing variety of tasks either in public or private spaces. Especially used for substituting humans in jobs characterized by low creativity or high life-risk factors. An interesting trend within this field is the development of capabilities to produce highly personalized items with the advantages of economies of scale. For instance a robot creating fresh sandwiches according to the recipe provided by the customer.

4. Consumer Robotics – social robots, robots for telepresence, educational robots, or the ones used for entertainment. This field is connected to the idea of “one robot for every household”. These machines can substitute humans in small tasks performed in the home environment.

Appendix 1. The Workshop's Agenda

9:00 Welcome and introduction to the themes of 3DCentral

Wojciech Przybylski – Chair of the Management Board of KPT , Monika Machowska –Project Coordinator for 3DCentral

9:30 Opportunities for the robotics growth from the EU perspective – strategies, goals, and milestones

10:45 Financing opportunities using EU, national and regional Funds

Agnieszka Górniak – Marshal Office of the Malopolska Region (Department for Regional Policies)

11:00 Coffee break

11:15 Barriers to access to funds

12:00 Significant regional projects and activities

13:00 Lunch

13:50 SWOT Analysis of Malopolska in the context of robotics

15:15 Coffee Break

15:30 Recommendations for developing robotics in Malopolska

16:00 Definition and identification of key topics for the region

17:00 Workshop completion