Quark®

Research and Development in Slovenia

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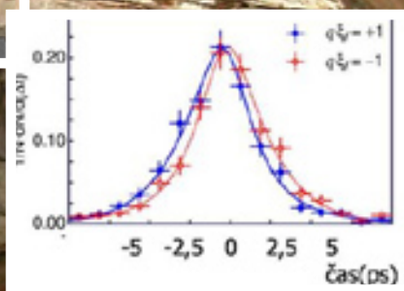

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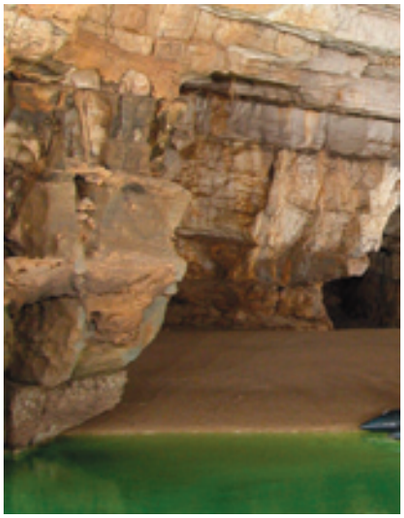

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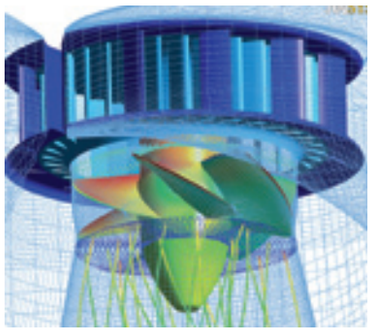

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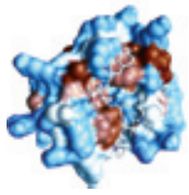

Excellent NMR Future Innovation for Sustainable Technologies
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What are the best environments for achieving the desired research and development results?

The global economic crisis has saddled countries with the need to conduct more thorough examinations of their economic potentials and to consider everything that could foster accelerated economic growth. Research and development capacities are no exception; on the contrary, in many countries they have been pushed to the forefront. Mainly as a result of competition, the most developed countries have in particular become more committed to the field of technological development and the promotion of scientific research whose results create new opportunities. Slovenia has taken a similar tack. In this issue of Quark we report on various activities which could be defined as important, perhaps even the most important recent developments. We present Centres of Excellence and their concentrations of knowledge in institutes, universities and companies. For Slovenia, which does not have any major global companies with sufficient capital for a strong concentration of development activities, they represent the filling of a gap and are therefore all the more important. The high technological level of these companies is an important goal, but it also means the further concentration of Slovenia's excessively dispersed development potentials for inclusion in the EU. Here as well they are filling a gap, both on a Slovenian scale and on a global one, since the EU is open to it. The establishment of CoEs in Slovenia is supported by EU funds.

Another significant point worth mentioning is presentations by scientists in the Slovenian National Assembly. Through them we present our readers with overviews of individual scientific fields on a popular science level, or brief views of the current developments within these fields. This will make interesting reading for many people. Everyone connected in any way with science and R&D is sympathetic towards such admittedly modest but media-supported gestures of support for scientific activities, through which the National Assembly has contributed to the creation of a favourable climate for both science and R&D.

Boris Čerin, Editor of Quark

The National Assembly, Lecture title:
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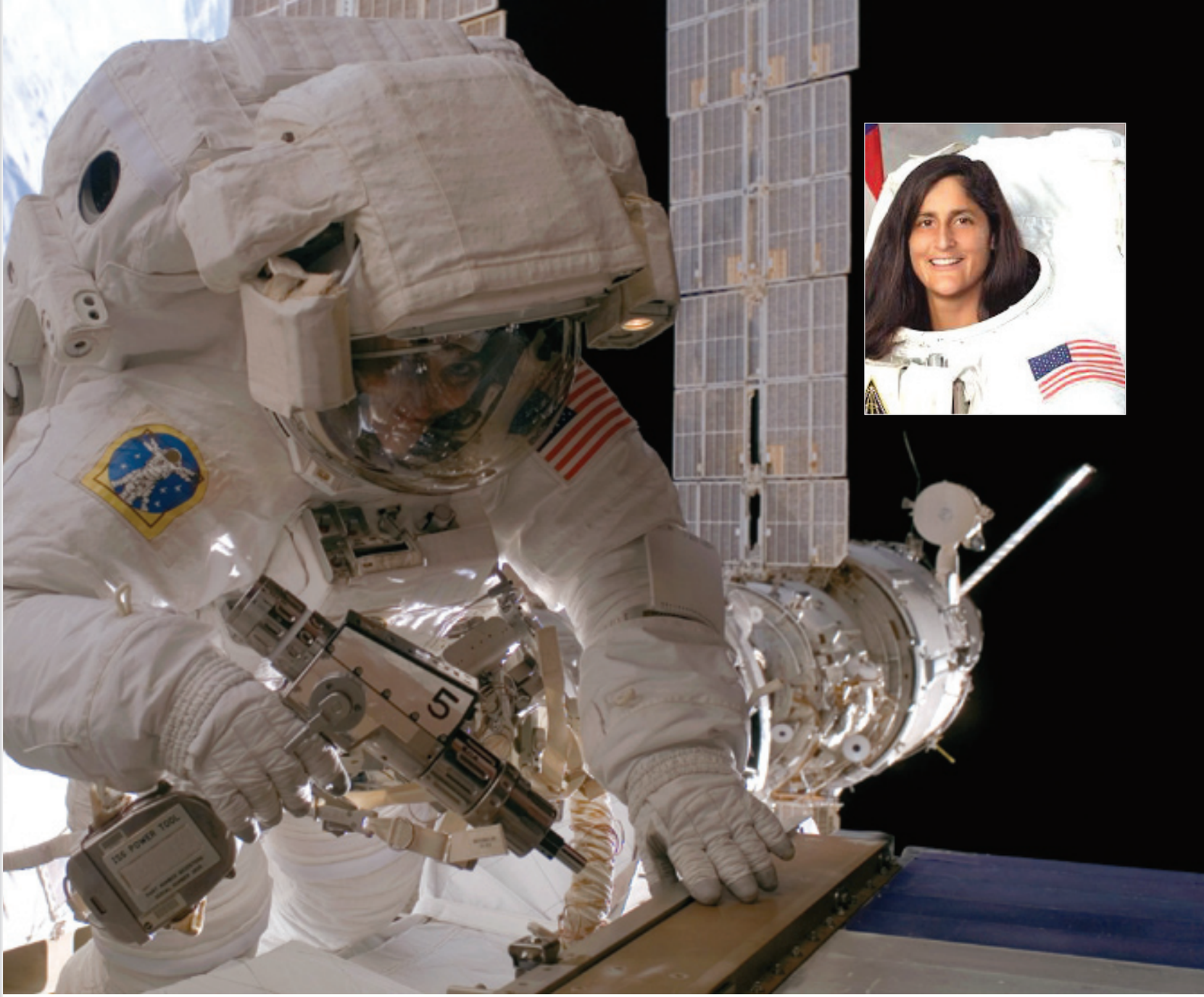
SPACE CITIZEN PAYS VISIT TO SLOVENIA

Edvard Kobal

Sunita L. Williams, an American astronaut of Slovenian-Indian origin and a citizen of space, paid a visit to Slovenia in September 2009. Her visit was one of the most important media events in Slovenia.

Slovenians are known as talented leading researchers in numerous scientific research-and-development and technological areas. However, in astronautics, we are especially proud of Sunita L. Pandya Williams, the first Slovenian astronaut. She is not only Slovenian, but also Indian and American, which makes us no less proud of her. Thanks to cooperation between the Slovenian Science Foundation and NASA, the American space agency, Sunita Williams visited Slovenia in September 2009 to promote human space travel, and resulting achievements over the last 50 years, at the 15th Slovenian Science Festival, a leading scientific event with international participation.



Astronaut Sunita Williams broke the record for the longest single spaceflight by a woman when working out of the International Space Station (Photo: NASA).

Astronaut Sunita Williams with young participants at the 15th Slovenian Science Festival (Photo: SSF archive).

View from a helicopter of Leše near Tržič, the birthplace of the astronaut's great-grandmother (Photo: Milan Malovrh).

Sunita Williams with Dragoljuba Benčina, State Secretary at the Ministry of Foreign Affairs, and Dr Edvard Kobal, director of the SSF (Photo: Janez Vlachy/SSF archive).

Sunita Williams is the first NASA astronaut of Slovenian origin (on her mother's side) (Photo: NASA).

The significant achievements of people of Slovenian origin in contributing to space programmes as scientists and/or astronauts adds further proof of the extraordinary creativity and talent of Slovenian people.

The first generation of astronauts of Slovenian origin within the NASA space programme were born in Slovenia. – Dušan Petrač, born in 1932 in Kropa, and Anton Mavretič, born in 1934 in Boldraž near Metlika. Both received their first degrees in Slovenia and finished their PhDs in their new country, the USA. As soon as they finished their PhDs, both joined space programmes. Later generations of space professionals of Slovenian origin were born in the countries in which their parents or grandparents had settled. An interesting case is that of Marcos Bavdaž, born in 1962 in Brasilia. At the age of ten, he moved with his parents to Austrian Carinthia, and finished his bachelor's degree in physics in Vienna, and his PhD in Hamburg in 1988. After completing his PhD, he joined the European Space Agency. Current NASA astronauts of Slovenian origin are Ronald Sega (born 1952), Jerry M. Linenger (born 1955) and Sunita Williams (born 1965).

Sunita Williams with Dr Ljubica Jelušič, the Minister of Defence (Photo: Ministry of Defence of the Republic of Slovenia).

Sunita Williams with her mother, Bonnie Pandya (Photo: Miha Šorn/Adria Airways).

From helicopter pilot to astronaut

Sunita Williams was born on September 19, 1965 in Euclid, Ohio, the third child in an Indian-Slovenian family. Her father, Deepak Pandya, came to the United States as a medical student and went on to a successful career in science. Her mother, Bonnie Pandya (born Zalokar), is a nurse born to Slovenian immigrants who settled in Cleveland at the beginning of the 20th century.

Sunita Pandya spent her childhood and youth in Needham, Massachusetts. Later, she became a student at the U.S. Naval Academy in Annapolis, Maryland. She was trained as a military helicopter pilot and also became a test pilot. She married pilot Michael Williams in 1989.

During her training as a pilot, she visited Johnson Space Center in Houston, Texas. There, she had the opportunity to meet many astronauts and also John Young, a legend in among astronauts as the first American to orbit the Earth. She was impressed by him and decided to apply for the NASA astronaut corps. She succeeded at the second attempt and in 1998 was assigned to the astronaut corps.

During her training as an astronaut, Sunita Williams became well acquainted with the space shuttle as well as with the International Space Station. She spent many hours with experienced instructors and tested her stamina and inventive faculties under extreme living conditions, similar to those on the International Space Station, which is some 400 km from the Earth.

Mission in space and on Earth

She was launched into space on the shuttle Discovery on December 9, 2006. She spent 195 days in the International Space Station. Among other assignments, she performed scientific experiments, worked on the robotic arm and was engaged in helping to complete and repair the space station. On this mission, she broke the record for the longest single spaceflight by a woman.

She returned from space on June 22, 2007 and became Deputy Chief of the Astronaut Office in Houston, and on December 1, 2008 was promoted to the rank of Captain in the US Navy.

Visit to Slovenia

Sunita Williams came to Slovenia on September 19, 2009, her 44th birthday. During her stay in Slovenia she met many individuals, including the Prime Minister, Borut Pahor, the Minister of Defence, Dr Ljubica Jelušič, the Minister for Slovenes Abroad, Prof. Dr Boštjan Žekš, and the State Secretary at the Ministry of Foreign Affairs, Dragoljuba Benčina.

She also paid visits to the Slovenian Academy of Sciences and Art, and the Slovenian World Congress, and met representatives of the Slovenian Science Foundation, who invited her to a ceremonial dinner and awarded her honorary membership in the Club of Friends of the Foundation. The charismatic astronaut was also given a reception at the headquarters of the BTC joint-stock company and Adria Airways (Slovenia's national air carrier). Memorable meetings with local people were organised in Vitanje, where the memorial centre for Herman Potočnik Noordung, the Slovenian spaceflight visionary, is developing, and in Leše near Tržič, the birthplace of Sunita's great-grandmother.

The culmination of her visit was her participation at the 15th Slovenian Science Festival with international participation, which was held September 22 24, 2009 in Ljubljana. Together with Prof. Dr Dušan Petrač, a long-time NASA Jet Propulsion Laboratory researcher in Pasadena, she presented the development of space science and technology during the last 50 years, with an emphasis on the 40th anniversary of the first manned landing on the Moon. She spoke with admiration about Neil Armstrong, a member of the first crew to land on the Moon, who inspired her to become an astronaut. The participants enjoyed her stories about spaceflight and her debriefing on a typical 24 hours in the International Space Station. Mrs Williams advised young people at the meeting to think hard about their future studies and encouraged them to give priority to natural science and technology in their life missions. In addition, she expressed a wish to meet Slovenian astronauts in the near future.

Sunita Williams finished her first official visit to Slovenia and returned to the Johnson Space Center, Houston on September 27, 2009. On her return, she began preparations for a joint space mission of American and Russian astronauts scheduled for 2012.

Sunita Williams in discussion with Prime Minister Borut Pahor at the opening of the 15th Slovenian Science Festival with international participation (Photo: Slovenian Press Agency).

Sunita Williams with Prof. Dr Boštjan Žekš, the Minister for Slovenes Abroad, and his colleagues (Photo: Government Office for Slovenians Abroad).

The opening address was given by Dr Danilo Türk, President of the Republic of Slovenia.

The 60th Anniversary of the Jožef Stefan Institute

Boris Čerin and Polona Strnad

To mark the 60th anniversary of the Jožef Stefan Institute, the Days of Jožef Stefan – which the institute organises every year on the birth date the Slovenian physicist after whom the institute is named – focused on the official ceremony marking the 60th anniversary of its founding. Prominent guests from politics, science and industry honoured the event with their presence.

The opening address was given by Dr Danilo Türk, President of the Republic of Slovenia, expressing his views on the position of science and scientific activities in Slovenia. He pointed out that development issues are currently the subject of discussions in the field, proving that science is necessary for further global development, as well as the development of individual societies, especially our own. President Türk argued that science cannot perform miracles and that nobody should believe that science alone can guarantee successful development. To support science, we need to establish networking, and synergy between science, industry and politics. Each of these activities has a very important role in development, and it is clear, of course, that synergy that excludes science cannot be effective. Knowing this, and with our recent experience of the economic crisis – which exposed the risks of rapid wealth accumulation and of virtual development, making us appreciate the importance of a real economy, real knowledge and real science – we must think about science in a thorough and critical way.

While further explaining his views on the role of scientific activities in Slovenia, President Türk also emphasised the importance of Slovenia's integration into Europe, as well as the importance of the intensive and varied forms of cooperation within the European Union, which are becoming increasingly recognised as integrated research and development within the European Union.

One of the basic arguments advanced by Dr Türk is that science is, in its essence, an international, or transnational, activity, which is why international comparisons of research institutes and individual researchers are necessary. Here he also pointed out that the Jožef Stefan Institute sets a very good example to other Slovenian researchers and scientists; however, the world continues to change, and it is changing in a way that requires our full attention. One of these changes is the creation of integrated research and development within the European Union. During the Slovenian presidency of the European Union, we saw the adoption of documents aimed at setting up an integrated research area to include all Member States by 2020. Within this area, the barriers to a free exchange of scientists and researchers are to be gradually removed. This idea may at first appear simple. However, its realisation will be demanding as it requires, in addition to the exchange of intellectual findings and scientific information, provision of conditions allowing young researchers, young scientists and other scientists and researchers to change their locations and posts more frequently and more intensively than Europeans do today, while maintaining their social security and a satisfactory income.

Speech given by Prof. Dr Jadran Lenarčič, Director, at the Ceremony Marking the 60th Anniversary of the Jožef Stefan Institute:

"Dr Danilo Türk, President of Slovenia, Dr Pavel Gantar, President of the National Assembly, Mr Borut Pahor, Prime Minister, Mr Blaž Kavčič, President of the National Council, ministers, your excellencies the ambassadors, distinguished guests, former directors of the Institute and the Institute's honorary members, prize winners and friends, welcome to the ceremony marking the 60th anniversary of the Jožef Stefan Institute, which is being held on 24 March, the birth date of Jožef Stefan – and the date when Anton Peterlin died.

The Jožef Stefan Institute (JSI) grew from the physics department of the Slovenian Academy of Science and Arts, founded in 1946, and from the Physics Institute, which was set up in 1949 to focus on nuclear-energy research. In 1952, this institute was renamed the Jožef Stefan Physics Institute; its main buildings were completed at the crossroads of Jamova and Jadranska streets in Vič, Ljubljana, and in 1959 it was again renamed, this time to the Jožef Stefan Nuclear Institute. Finally, in 1969, it was given the name we still use today, the Jožef Stefan Institute.

Academician Prof. Dr Anton Peterlin, the first director, provided its scientific foundations and organised the institute. We celebrated the centenary of Prof. Peterlin's birth in September 2008 by publishing a book about him, in partnership with the Slovenian Academy of Science and Arts. This academy was the founding body of the institute; however, in 1970 the activities of the founder were transferred to the University of Ljubljana. In 1992, the Republic of Slovenia became the institute's statutory founder and the name University of Ljubljana was removed as the institute became a public research institution. This legal arrangement was introduced as a temporary one; however, the core characteristics have remained unchanged, and today the situation is still problematic.

By 1959, the Institute already had 300 employees; today it has about 870; and with the increasing number of young researchers, this number continues to grow. The JSI is by far the largest research institute in Slovenia, as well as being the country's only multi-disciplinary institute. As such, it stretches across national borders and I can say – and I have no need to be modest here – that its name is recognised throughout the world and that the JSI helps to create a Slovenian cultural identity. A great deal of knowledge is concentrated at the JSI, as it employs about 400 researchers with PhDs, of which at least 200 are professors at various universities. In addition, another 200 researchers are studying for their PhDs.

I believe that the JSI has played an important role in establishing and developing Slovenian natural and technical sciences. In the 1950s, the JSI introduced a betatron, an electron microscope, and a Van de Graff accelerator. Later, nuclear magnetic resonance was introduced, one of the first analogue computers was built, the first microcomputers and first robots in Yugoslavia were created, the Internet was adopted, and XeF6 and stefin were isolated. In 1966, the Triga reactor began to operate in Podgorica and the world's first digital oscilloscope with an LCD monitor was produced. Today, we deal in research relating to synthesis of nano-materials, in nano-microscopy, etc. There are far too many pioneering achievements to mention all here.

In 1992 the JSI had more than 900 employees, but this number decreased significantly when it set up the Technology Park, which later expanded to become the Technology Park Ljubljana. In 1996, the JSI set up the Polytechnic in Nova Gorica, which is now known as the University of Nova Gorica, and in 2003 it set up the Jožef Stefan International Postgraduate School, which now has 220 postgraduate students. The JSI has also set up other, smaller institutions, such as Erico in Velenje or the Research Institute of the Valdoltra Hospital.

Like our founder, Dr Peterlin, I believe that science and research are part of our personal and national culture, even in the case of

Photo: Marjan Smerke

Prof. Dr Jadran Lenarčič, Director of the Jožef Stefan Institute.

Dr Danilo Türk, President of the Republic of Slovenia:

"We must ask ourselves what science really is. We are familiar with its definitions, of course, and with its findings. However, we are facing new social challenges. Science has always been the activity that can, on the basis of the strict scientific method, provide new and real knowledge. If today we perceive science in the context of new developmental challenges, should not one of our expectations be that science creates wealth? Do we see science as both the creator of new knowledge obtained on the basis of strict methodological criteria and of new wealth? Is it appropriate that scientists and scientific institutions should aim at creating new knowledge and, even more so, new wealth? Is it then also appropriate that the networking scientific institutions and industrial companies should act more ambitiously and include scientists directly in the operations of companies, while companies, along with their managers, need to provide the conditions necessary for such cooperation? We are probably obliged to think now about technologies such as membrane technologies or nanotechnologies not only in terms of acquiring new knowledge, but also in terms of generating new wealth, looking for links between industry and science that can allow the creation of new wealth. Politics, of course, should also be involved in this process, as the legislative and executive powers of politics can provide an important part of the conditions necessary for such co-operation. With respect to the above, today, we can be pleased that the most prominent representatives from our legislative and executive authorities are here with us, celebrating the anniversary of the Jožef Stefan Institute, and proving in this way their commitment to searching for new paths that will link science and industry, as well as science, industry and politics.

Photo: Marjan Smerke

We have several reasons for redefining the above issues in Slovenia: not only those associated with the economic crisis, but also related to the organisational aspects of our country. A large amount of money, close to 6% of GDP, is allocated for education; however, we still have a shortage of certain important specialists, and precisely in those areas in which the Jožef Stefan Institute is especially strong – mathematicians, engineers, natural scientists and other. This is a problem that would require our attention at any time. Today, facing the crisis, we must think about this problem even more intensely. We also must whether the share of GDP allocated to science is large enough. Currently, this share is about 1.5%, which puts us about 25th in the world. However, with respect to the cooperation between science and industry, using the current criteria that are often quoted, we do not rate that highly. Our current financial contribution to this area does not result in the required level of co-operation. We are roughly 43rd in the world on this measure. Therefore, we should ask ourselves not only whether we should increase the funding that society allocates for scientific development and how we do this, but also how to distribute funds within society in order to increase co-operation between science and industry. This is another of the basic issues that we must think about today."

natural and technical sciences. Tolstoy said that pleasure is not in the truth, but in the seeking of the truth. For me, creative activities are at the pinnacles of human endeavour. When Einstein's theory of relativity was proven with measurements for the first time, he was asked whether he would be disappointed if the measurements indicated that his theory was not correct. Einstein replied that he would only be sorry that God did not yet know of the theory concerned. However, instead of dwelling on the past, I would today prefer to focus on the present and the future. But while doing this, I cannot ignore the fact that Slovenian science and technological development are still not recognised as the foundations on which Slovenia should base its development policy. Although all the country's strategic documents give science and development a central position, the public can only see these as the domain of a small circle of enthusiasts. In Slovenia, we do not focus intensely enough, and to a sufficient extent, on science and technological development, and neither do we give enough focus to the wider aspects of knowledge, creativity, innovation, and new ideas – in short, on the culture of progress. We have not yet placed this culture of progress in our field of vision, or at least we have not yet brought it into focus. Instead, we are continually engaged with unimportant problems.

If we ask ourselves why this is the case, we find an answer, but a very unpleasant one for us: the reason is our poor understanding of the creative processes, i.e. the processes of creating original ideas and acquiring new knowledge, and transforming scientific discoveries into cutting-edge technological products that can be successfully sold or integrated into everyday life. As a society we do not recognise the key developmental issues at all. For this reason, we are not able to find solutions and the above processes occur sporadically and on the basis of the personal efforts of a few individuals working

in science and industry. It is high time we asked ourselves how we should determine our vision, how to undertake development and how to achieve the set goals. One Nobel Prize winner said that his mother had never asked him what smart things he had heard at school; rather she wanted to know what smart questions he had asked during his lessons. It is, therefore, necessary to first recognise the key challenges relating to our development. Statistical comparisons with Finland, Germany, Ireland or France will not help us achieve the breakthrough that we wish for, and that I believe we are capable of when we make real effort and use our skills. I will again, for the hundredth time, repeat my belief that we cannot expect different results if we continue to apply the same old methods. Not even scientists can conjure up such magic. Slovenian society has to completely change its attitude towards its most creative members. Although I feel weary of repeating myself so much, I do remain optimistic. Mark Twain once said that many children have parents that are difficult to bring up. So we should not give up just yet.

Since the start of its work, the JSI has had strong ties with university-level education: in the past mostly with the University of Ljubljana, but now also with other universities, such as the University of Primorska, the University of Maribor, and above all with the University of Nova Gorica and the Jožef Stefan International Postgraduate School, as these last two were initiated by the JSI. In the past, links with the University of Ljubljana proved to be of key importance to the JSI, and I believe that the University of Ljubljana, at least its natural-science and technical depart-

At the front: Mr Borut Pahor, Prime Minister, Mr Blaž Kavčič, President of the National Council and Boštjan Žekš, Minister for Slovenes Abroad.

ments, also profited from these links to the same extent. Even as a first-year university student, I personally felt the influence of the JSI when I was attending the lectures in physics given by Prof. Milan Osredkar, then the director of the JSI. Professor Osredkar used to orally examine all the students at the same time. He would set a question for the first student on his left. If that student did not answer, the professor would set the same question for the next student; if he failed as well, the professor would continue asking the same question until he got the right answer from one of the students. He always started setting a new question for the same student and followed the same procedure. As a result, the professor never reached the students that were sitting more towards the back of the group. On one occasion, when the students at the front failed to give the correct answer to a simple question, the professor became so angry that he failed all the students that could not answer his question and gave a pass to the rest of the students. Later, as we were leaving the hall, he also said that students like us should not be allowed to attend university. Thus, I ended up at the JSI.

Unfortunately, cooperation between public research institutions and the university programmes is not determined by any law and is mainly carried out on a personal basis. The results of such joint working thus depend solely on the individuals involved, so that there are both ideal relations as well as some examples of very poor projects. However, I can assure you that the best research groups are those that are based on a symbiosis, where the students or researchers do not even know whether they work for the university or for the JSI.

Our researchers must compete with their colleagues from around the world; if they failed to do so, their existence would be undermined. However, it is easy to imagine how difficult this competition is when the funds supporting our researchers are four times smaller than the funds supporting colleagues in Germany or Finland. We keep saying that co-operation between science and industry in Slovenia should be better. However, it must be pointed out that the situation is not as bad as it may seem, although it should be much better. We tend to blame each other for causing the difficult situation, scientists pointing at politicians and industrialists, politicians pointing at scientists and industrialists, and the latter blaming politicians and scientists. Each of the three groups knows what the roles of the other two groups should be, but none can clearly see their own roles; none of them knows exactly what they should do to play their roles effectively. This reminds me of Charlie Chaplin taking part in the competition to impersonate Charlie Chaplin, where he was placed only third. There are insufficient links between science and industry, because this cooperation occurs in a kind of no man's land – a nightmarish situation. Neither money nor social recognition is to be found in this area. And in the past fifteen years, this country has not done anything to support such partnerships, providing neither the money nor the appropriate mechanisms. I dare say that without a comprehensive approach to bringing together science, industry, politics, administration and public interests, our generation will not carry out its tasks. It looks as if we are afraid of large development projects, public-private partnerships, enterprising researchers, and joint-development groups, which bring together researchers from institutes and industry. Instead of being involved in these activities, we are continually regulating something, for example, salaries in the public sector, trying to democratically distribute the funds instead of investing them as suggested by Dr Žekš. I am taking this opportunity to recall again the driver of a Formula 1 racing car who was asked, during a race, whether he had everything under control, and who replied that if he had had everything under control he would have been going too slowly. I would like to add that he would also have been going in the wrong direction. Using the words of Max Planck, I should like to point out that knowledge is the basis for applications, meaning that good basic research forms the grounds for good applied research and technological development. Similarly, and to the same extent, good applied research provides the grounds for good basic research, as it helps us formulate smart questions. No other formula can be used here.

A cornerstone of the JSI is its international cooperation. The JSI annually carries out 120 projects within the EU's sixth and seventh framework programmes, a figure which is increasing at an annual rate of 50% and which already represents 15% of our total income. Furthermore, all our young researchers are obliged to enhance their knowledge with an extended stay abroad if they wish to obtain the title of scientific researcher and a permanent contract of employment. Consequently, each year about 80 members of staff are away from the JSI. There is almost no important research going on at the JSI without links with partners abroad, and each year the JSI is cited more than 12,000 times in international scientific journals, a figure which I believe is comparable with those achieved by other top-level research institutions around the world. For these reasons, I think we can consider the JSI as both an ambassador and a "trademark" of Slovenia.

Unpredictable times are ahead of us. For now, we know only that the situation tomorrow will be more difficult than it is today. To overcome the crisis successfully, one must be an optimist, yet not an ignorant person, let alone a greedy one, which is a widespread psychological profile these days. The winners of the future will certainly be those that spend less and invest more, mainly in knowledge and new technologies. Let me be optimistic here and call to mind the words of Balzac, who said we should not lose our heads in a bad situation, as no problem is so bad that it could not be worse.

The JSI would not be the same without strong links to its partners i.e. universities, institutes, other public and private institutions and, of course, to industry. Let me mention only a few of our large industrial partners – Gorenje, the Krško Nuclear Power Plant, Domel and Trimo. Please excuse me here for thanking our partners without mentioning all the individual companies by name.

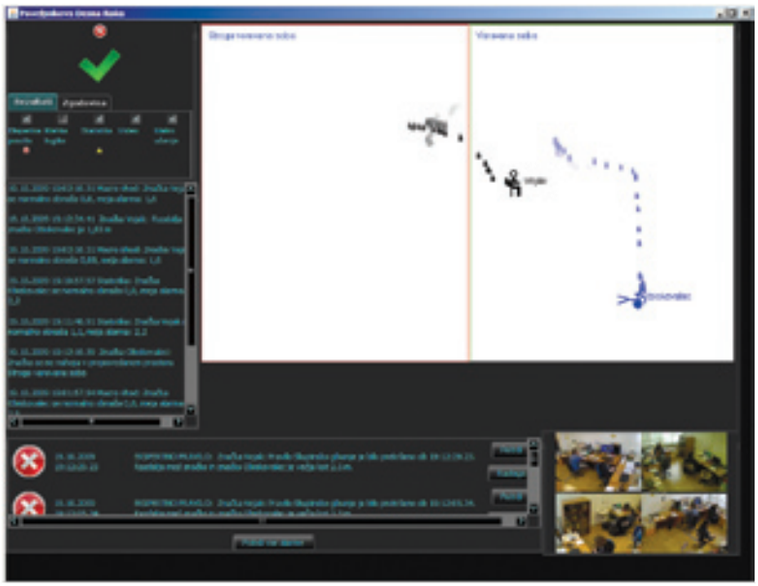
Dear colleagues, it is a great honour and pleasure for me to be a member of this eminent institution. If I had to remove something out of my life, it would surely not be the day when I became a member of the JSI – a place one never wants to leave. I would like to thank everybody that has helped us to build the JSI. Dear Mr President and other distinguished guests, colleagues and friends, our generation had an opportunity to enter the wonderful world of science and technology, let us make it possible for the next generation to have its opportunities as well. Long live the Jožef Stefan Institute!

Best National Innovation Award for Commander's Right Hand

Matjaž Gams, Rok Piltaver

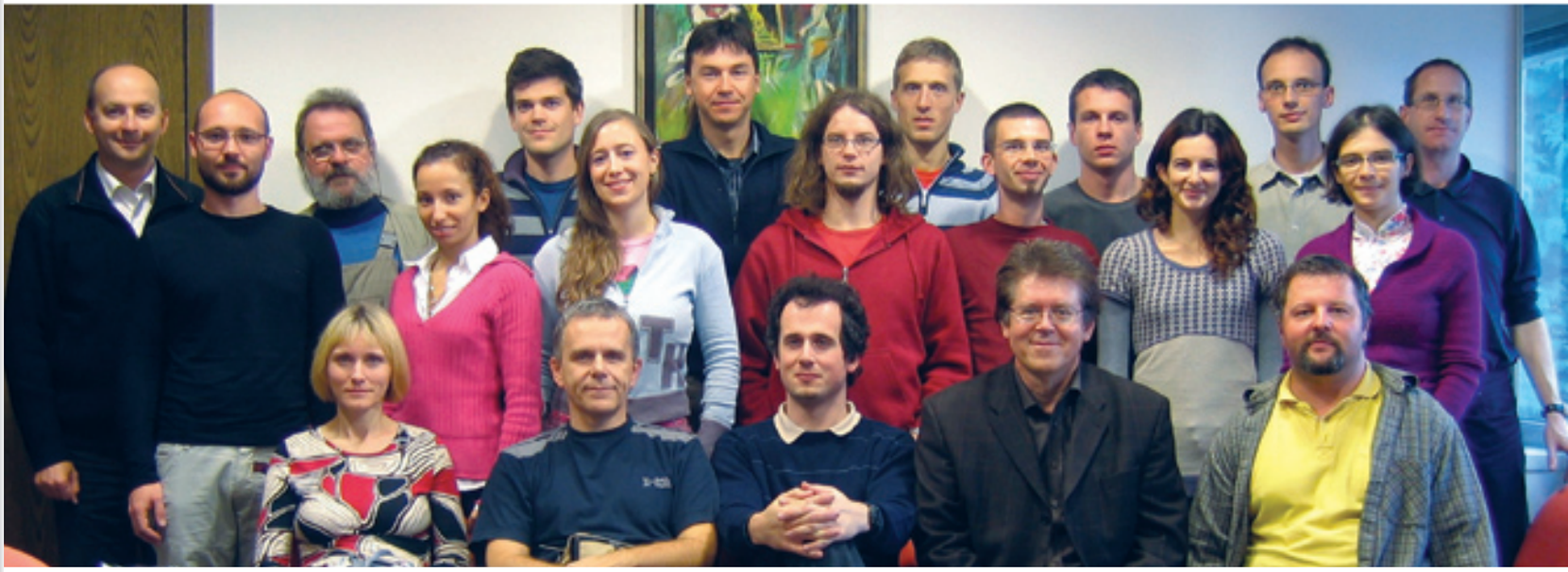
The prototype of the intelligent security system named Commander's Right Hand (Poveljnikova desna roka) was presented at the Fourth Slovenian Innovation Forum, where it received the award for the best innovation among research and development organisations in Slovenia for 2009.

The innovation stems from a targeted research project financed by the Slovenian Ministry of Defence as a part of the research programme "Science for security and peace 2006–2010". Three partners – the Department of Intelligent Systems (E9) from the Jožef Stefan Institute (IJS), Špica d.o.o. and the Faculty of Electrical Engineering Ljubljana – developed a prototype of an intelligent system for surveillance of movement of personnel and equipment. A commercial real-time location system and an advanced video system track the locations of people and equipment while novel AI methods assess the security situation. The PDR system automatically learns normal movements and also uses predefined knowledge about permitted events. If unusual, suspicious or forbidden activities occur, the system alerts the commander and provides data about that event for later analysis. Examples include a visitor that has moved away from personnel, an unidentified moving object, a person lying immobile on a floor and unusual movement of an employee. The project began in 2007 and was successfully finished in 2009 under the guidance of the Slovenian Ministry of Defence supervisors Anže Rode and Dragomir Čevriz. See demo videos at the following link: http://www.youtube.com/user/ijsdis. Because of the success of the project, the E9 department was invited into the European Defence Agency (EDA) project as the only Slovenian partner for 2009. A patent application is in progress.



The graphical user interface of the prototype intelligent system

The award for best innovation



VITEL 2010

International Workshop on Telecommunications

TRANSITION TO IPv6

Brdo – Kranj, 19 and 20 April, Slovenia

A. Robnik, M. Jagodič

The Slovenian Society for Electronic Communications (EZS – SIKOM), a sister society of IEEE Communications Society, has a very long tradition in organising national and international events on telecommunications in Slovenia. The intention of the events has always been to concentrate on the most important and relevant topics at the time leading to more efficient and useful or simply viable telecommunications for everybody. This principle also explains the name given to these events which is VITEL (VIable TELecommunications).

A. Robnik, Chair of the Organising Committee

M. Jagodič - Slovenian Academy of Engineering Sciences,

VITEL is guided by its International Advisory Committee composed of well-known telecommunication experts primarily from the Central and East European Region and chaired by Dr Marko Jagodič. The selection of papers and creation of the final programme is prepared by the Programme Committee composed of eminent telecommunication professionals from Slovenia and chaired by Alojz Hudobivnik from Iskratel. The Organising Committee, responsible for the realisation of the event is different for each event. This one was chaired by Ana Robnik from Iskratel.

The committees decided to select "Transition to IPv6" as the appropriate theme for the VITEL 2010 International Workshop with the objective of bringing together experts from operators, service providers, academia and industry alike to address this very important topic for the future development of telecommunications and the Internet. The event was sponsored by the IEEE Communications Society Chapter of Slovenia, the Ministry for Higher Education, Science and Technology and the Ministry for the Economy.

Multimedia-rich communications in modern converged fixed and mobile networks have triggered a rapid increase in the number of end-points, particularly mobile users, and rapid expansion of all IP-communication infrastructure, boosting demand for IP addresses well beyond the capacity of the IPv4 address space. Theoretically only 4.3 billion users can be connected with public IPv4 addresses. Therefore desktops in various organisations, mobile phones and stand-alone devices use private address space, connected to a single or a few public IPv4 addresses. With network address translation and usage of private addresses, instead of public, 3G community and service providers solved in the short term the problems with the shortage of IPv4 address space, which they received from the Internet Assigned Numbers Authority (IANA) or the Regional Internet Registry for Europe (RIPE). As a consequence, the network providers have been facing many problems with the complexity of managing such networks, the visibility of end users in public networks, and conflicts between IP addresses in merging such networks.

An accelerated transition from IPv4 to IPv6 has thus become one of the most important conditions for efficient realisation of the future Internet, which is listed among the four priority areas for investment in the Digital Agenda for Europe.

N. Simič, the opening address

The workshop took place in the Congress Centre Brdo – Kranj on 19 and 20 April 2010. Nikolaj Simič, the General Director of the Directorate for the Information Society of the Republic of Slovenia opened the workshop. In his opening address, he highlighted the extreme importance of the theme and its short-term and long-term influence on the evolution of future telecommunications and the Internet. Presentations for the workshop were prepared by representatives from universities, ministries, the regulator, network operators, providers of services and applications, and equipment vendors and suppliers. The most high-profile foreign participants were Teemu Savolainen from Nokia and Marco Hogewoning, co-chair of the RIPE IPv6 Working Group.

On the first day of the workshop, the status of the transition to IPv6 in Slovenia and around the world was discussed, along with the existing transition strategies of major equipment vendors and network operators, together with problems encountered. Although using strategically different approaches for the transition to IPv6 around the world, the achieved results and experience are encouraging. What is cause for concern is that far fewer countries that have decided to make this transition to date than expected. The main reasons are the rather high costs, which are difficult to justify, and the lack of interest in making the transition across the whole chain starting with users and providers of services and applications. A major deficiency is also the lack of backward compatibility with IPv4. Therefore it is extremely important that a very detailed and systematic plan is in place before the actual transition starts.

The first day ended with a roundtable entitled "Transition to IPv6 – Waiting for Godot" The roundtable, moderated by Dr Mitja Štular, was very provocative and inspiring. One of the most significant results was the decision to prepare a document for the Directorate for the Information Society of Republic of Slovenia, which will serve as the basis for its future activities in this area.

On the second day, examples of good practice were presented and discussed, based on different strategies, different network and service environments, and different business or technology initiatives. The workshop was concluded with the presentation of transition mechanisms "Dual-stack light", "6RD", "A+P" and others.

More information about the workshop can be found at http://www.sikom.si/

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Deans of the University of Ljubljana

At the front: Mr Borut Pahor, Prime Minister and Mr Milan Kučan, the former president of the Republic of Slovenia.

Dr Stane Pejovnik, the new rector of the University of Ljubljana

The President of the Republic of Slovenia Dr Danilo Türk as the speaker of honour.

Ninetieth Anniversary of the University of Ljubljana

In 2009, the University of Ljubljana celebrated 90 years of uninterrupted operation. The principal celebration was held on 1 December 2009 at Cankarjev dom. This important university anniversary was marked by lecturers and students, representatives of foreign universities and VIP guests from politics and industry. The guests were addressed by the rector of the University of Ljubljana, Prof. Dr Radovan Stanislav Pejovnik, the President of the Republic of Slovenia, Dr Danilo Türk, as the speaker of honour, and the student representative, Ana Pleško. The University of Ljubljana celebrated this anniversary by publishing a monograph on "90 Years of the University of Ljubljana – Between Tradition and the Challenges of Time", introducing all of its members and the Rector's Office in detail. As in every year, the University of Ljubljana awarded honorary titles to a number of eminent individuals.

The new rector Prof. Dr Radovan Stanislav Pejovnik:

“We are proud of being able to boast such a rich tradition and such wide recognition in the world”

90 YEARS OF THE UNIVERSITY OF LJUBLJANA

Boris Čerin

I met Prof. Dr Stane Pejovnik, the new rector of the University of Ljubljana, 18 years ago for an interview for Quark, a little over a year since its inception. I was interested in the research being done at the National Institute of Chemistry and Professor Pejovnik, the then director of the institute, seemed to be the right choice for the article, considering its subject matter. “A scientist must have a comprehensive education,” the professor said at the start of our interview in 1993.He added: “this is an uninterrupted process ranging from basic education up to the highest levels of specialisation in a given field. In addition to acquiring knowledge, the process involves enlightening the person, the researcher, the mentor and finally the professor. For this to happen, it is essential that one ‘goes out into the world’. This is the prerequisite for developing fully and acquiring the breadth of mind that will allow you to make high-quality judgements.”
Thinking of this kind served as an introduction to the process of change as Slovenia was undergoing intensified European and world integration 18 years ago.

The 90th anniversary of the University of Ljubljana took place soon after your election as rector. Was this after the start of your mandate?

Yes. One of the first things I handled was organising the University’s 90th anniversary. I have to say that it was my pleasure and that much of the work had already been done by my predecessor, Prof. Dr Andreja Kocijančič. Heading a 90-year-old university is an immense honour that requires a great deal of responsibility, reason, respect and vision. I am convinced that we will reap new successes along with the nominated management team and at least preserve the reputation created by my predecessors.

There are certain features of the Slovenian space of that time that are again becoming more pronounced. Even before the University of Ljubljana was founded, Slovenia's geographical position allowed Slovenians access to the leading world education centres of the time. For example, the railway line to the capital city of the state that included all the regions of the Slovenia of today, Vienna (crossing a distance of over 350 kilometres at the time) was established as long as 150 years ago. This was an advantage because it gave scientists such as Jožef Stefan, who published a study on the heat conductivity of gases in 1872, an open path to their own discoveries. Was this openness to the world a characteristic of the Slovenian scene at the time, which is now again gaining in magnitude?

The openness to the world was always there. We now see it somewhat differently, though. The university is among the top 3% in the world. We are connecting with other universities, establishing branches across Europe, and our professors are invited as visiting lecturers to eminent universities around the world and vice versa. And, of course, there are the students. The number of foreign students increases every year. The university has therefore augmented the number of subjects conducted in English. A rising number of our students are also choosing foreign student-exchange programmes. In a way, the University of Ljubljana is becoming more and more integrated into the global environment, mainly on account of its success. We must not forget that the number of European projects we have been joining is on the rise, strengthening the university's inter-European networking. I must admit, though, that there is much to be done in two particular areas. The first, as I mentioned previously, is to offer more study programmes in English, and the second is to create a situation where there will be more excellent researchers and professors visiting our university. Unfortunately, the current climate is still one in which foreign researchers or professors are considered harder to accept. This will change though. I am sure of it.

Rector, Prof Dr Radovan Stanislav Pejovnik

Let us now go back to the founding of the University of Ljubljana. It has allowed a much larger percentage of the population to study, and considering the drastic growth of demand for doctors, engineers and professors at the time of its founding, it was high time that it was established. It should be noted that after the First World War, the Austro-Hungarian Empire broke apart, after which Slovenia became part of Yugoslavia, which it co-created.

The demand for establishing a Slovenian university had been a constituent part of the Slovenian political programme since 1848. The idea matured for some 30 years before finally coming to fruition. Up until the dissolution of the Austro-Hungarian Empire, Slovenian students had to study at neighbouring universities in Vienna, Graz, Prague, and later in Krakow, and a few at the University of Zagreb. Over a period of 30 years (1880–1910), the number of Slovenian students at Austrian universities and higher education institutions increased from around 350 (1880) to nearly 1,000 (1913). In June 1919, the University of Ljubljana was founded by the central government in Belgrade, chiefly thanks to the efforts of a small circle of influential men (Karel Verstovšek, the lawyer Danilo Majaron, and a professor at the University of Prague, Mihajlo Rostohar), against the opposition of some politicians and scientists who were calling to postpone the founding until the post-war situation was more settled. In August 1919, the first 18 professors were nominated for the first five faculties of the University of Ljubljana (the Faculty of Law, Faculty of Arts, Faculty of Theology, Faculty of Medicine and the Technical Faculty).

In summary, it is safe to say that the University of Ljubljana has contributed heavily to raising the education level in the Slovenian environment, both culturally and in the sense of providing the knowledge required for industrial and economic development. At this point, we come to the realisation that the university continues to operate towards ensuring progress in Slovenia. It is not the only institution doing so, but its share is still the most significant.

THE UNIVERSITY OF LJUBLJANA TODAY

As this interview is also intended for students, let us stop for a moment to compare events in sport and in the education system. The FIFA World Cup is now underway, and the events taking place there are interesting for quite a number of students. Let us discuss events such as those in football, in which at the end of various championships, teams are created from the best players, that is, teams consisting entirely of football stars. Every so often, it happens that these star teams lose to teams consisting of much less famous players who are better trained to work together. Teamwork is very important in football. In your opinion, how important is having a well-trained mind when solving demanding tasks and problems?

Let me first say that the university has recently signed a contract on co-operation on the senior team project with the Bravo football club. The team will be called "Bravo student" in the 2010/11 season. This will be an exclusively amateur football team, and the university's financial obligation will be light and closely linked to its capabilities.

Currently, there are few successful researchers who patent their inventions. This means conducting a market analysis, selling the patent at the highest price possible, and entering production – designing a production line and the relevant machinery. This is followed once more with further market research, selling for a large profit and investing the profit into more research and development. These people are extremely rare and this chain is not linear. It requires a comprehensive system, more accurately an intertwined system of policies, a fact of which we are not sufficiently aware. Many people try to find some kind of shortcut or cheaper alternative.
In professional literature, this system is called the triple helix (the interaction between the governmental, entrepreneurial and research policies) and it contains a group of points in a three-dimensional space. It is essential that all partners are within this harmonised environment. The environment must be stimulating. If companies see directors who acquire a favourable loan as being much more successful than those who introduce a new product, then directors will be inclined to seek favourable loans. The situation has changed, and cheap loans will no longer save directors; this mode of thought was exhausted in the previous government's mandate, before the world economic crisis.

With its education programme, the university is supposed to equip its students with the tools to think at a higher level. If we continue this thought process, we soon come to the realisation that there are several building blocks involved in this type of training. This primarily involves the professors' lectures and the method of presenting the given subject matter to the students.

With market needs being what they are now, it is the University's task to prepare its students for the world. The market needs university graduates with broad general knowledge, not narrow specialisation. We must consider the fact that every future university graduate will likely change their job three to five times during their lifetime. The University must provide high-quality general knowledge with the possibility of upgrading and specialisation if needed. When I was Dean of the Faculty of Chemistry and Chemical Tech-

Following the reception of first-year students at the start of the university academic year, students 'occupied' the centre of Ljubljana's Old Town.

nology, the pharmaceutical company Lek told me not to drive our students to specialise in what Lek is doing now, but rather give them a good knowledge of chemistry. Lek said that it would rather develop their specialisms later, in line with the current demands of the pharmaceutical market. I think the University of Ljubljana is already generating graduates of this kind.

Our talk started by commenting on the situation in our area before the university's establishment, but now the focus is on the present. So, the university has a new leadership, with specific tasks in focus?

I would like to emphasise that the University of Ljubljana is a fine high-quality research institution and that, despite inadequate funding, it ranks extremely highly on major international charts of university performance. The university has appropriate rules and internal regulations in place and follows them. For this reason, the new leadership has no need of starting out with grand reforms and changes. It is more important to ensure a system sustainable in the long term; the university above all needs creative peace and stability. The new leadership will, however, have to re-establish trust between the Rector's Office and the members, improve co-operation between the members and look for synergy in joint action and ensure that everybody works together – students, teachers and all the professional staff – to ensure sufficient funding for effective implementation of the reform of the study process and the accompanying research work.

On the whole, my view is that leading such an institution requires a great deal of coordination, respect for the distinctions between members, decision-making through democratic, yet well-led, debate and the completion of jointly agreed tasks. In this process, the rector is only the first among equals.

The new rector, Prof. Dr Radovan Stanislav Pejovnik

Foreword by the President of the National Assembly of the Republic of Slovenia, Dr Pavel Gantar to the Lectures Given Under the "Harvest of Knowledge" Project

National Assembly, 7 June 2010

Throughout the history of mankind, research and innovation were man's constant companions. His enquiring mind, exploratory spirit and tireless desire to discover and create new knowledge triggered the advancement of science and research, as well as the intellectual engagement of society. Driven by man's natural inquisitiveness, creativity became the driving force behind innovation and a key factor in social and economic development.

Nowadays, research and innovation, together with knowledge and technological development, present long-term impacts on the development of society. They are indispensable requirements for the achievement of strategic development goals, accelerated economic growth, the creation of new jobs and the welfare of the population, and are particularly important in light of the pan-European contingency measures designed to overcome the economic and financial crisis. Therefore, there can be no doubt that the future lies in the hands of a responsible, knowledge-based society, able to exploit its cultural potential, promote research and development, and generate economic development and new jobs.

Contemporary science has a greater influence than ever before. It has become an important and indispensable component of modern society. In fact, science is now inextricably linked to every aspect of our lives, making the dialogue between science, politics and society an everyday necessity. Expert and demonstrable information is of vital importance in political decision-making, as it is conducive to reaching the favourable and responsible conclusions necessary in order to achieve desired results and objectives. Thus, the National Assembly the body exercising legislative powers and significantly affecting social life strives to make science more accessible to the public. Thus, being aware of the increasing importance of science and research and, particularly, the fact that highly qualified, creative and enterprising individuals are the driving force behind development, about a year ago, the National Assembly opened its doors to renowned scientists to present their research work and achievements. Confident that the National Assembly's reputation and media attention paid to its work would serve as an effective instrument to promote science, we launched the "Harvest of Knowledge" project in March 2009, together with the Ministry of Higher Education, Science and Technology and the Slovenian Research Agency. The project, which follows the example of successful projects implemented in other developed countries, is intended to promote knowledge, science and innovation. Its purpose is to bring the achievements of Slovenian scientists closer to the attention of members of parliament and the public at large, and, at the same time, contribute to greater openness to change.

Since the National Assembly started the "Harvest of Knowledge" project, several Slovenian scientists have already presented their research work and achievements. Their studies and findings range from the disciplines of synthetic biology, elementary particle physics, cosmic ray measurement, nanotechnology and photonics to landslides and inspiring underground life incontestably, confirming that Slovenia's many eminent scientists contribute significantly to the world's treasury of knowledge.

In this time of growing interconnectedness and interdependence, it is a rather utopian ideal to expect that we will be able to cope with the global challenges of the modern world without society's collaboration in the realms of science, politics, the economy and the media. I am confident that with its "Harvest of Knowledge" project, the National Assembly also contributes a great deal to the process of cooperation, and thus to a better tomorrow for our citizens.

Dr Pavel Gantar, the President of the National Assembly

The National Assembly

Lecture title:

"Synthetic Biology: Potential for a New Scientific and Technological Revolution and Slovenian Excellence in Research and Education"

Lecturer: Prof. Dr Roman Jerala

Abstract

Synthetic biology is a young area of research with the potential for a new scientific and technology revolution that uses engineering methods for the modification and creation of novel biological systems. This is achieved through introduction of synthetic genes that contain the coding for selected cellular processes. Areas in which synthetic biology has already had an impact include new therapeutic methods, preparation of pharmaceuticals, renewable energy sources, preparation of materials with novel properties, information processing, etc. In the past three years, researchers from the National Institute of Chemistry and students from the University of Ljubljana have achieved incredible success at the International Genetically Engineered Machines competition (iGEM) at MIT. With our projects focused on improving health, we have shown that through inventiveness and motivation we can compete with the best in the world.

Key words: synthetic biology, biological engineering, scientific and technological revolution, HIV, sepsis, synthetic vaccine, bacteria Helicobacter pylori

Basic science has been key to the development of technologies that have strongly influenced the well being of people over the past few centuries. Over the last few decades, we have also realised that it may have a significant influence on the environment of our planet. From the 18th century onwards, the industrial revolution brought about a large leap in the quality of life and the wealth of nations. The second half of the 20th century was influenced by the unprecedented development in electronics. Over the last century, average life span increased by more than 30 years. The largest contribution to this was brought about by improvements in public health, in large measure based on biotechnological discoveries such as antibiotics and vaccines. It is certain that the next century will be marked by life sciences. In the past decades, we have seen an extraordinary development in our understanding of the functioning of cells and living organisms. We have at our disposal tools that allow us to solve the problems of humanity from health care to the exploitation of renewable

Slovenian iGEM team members from 2006–2009 in the Slovenian parliament together with members of parliament, government representatives and EU Commissioner Janez Potočnik.

(At the front) Slovenian Prime Minister Borut Pahor, Minister of the Interior Katarina Kresal, Minister of Transport Dr Patrick Vlačič and Minister of Public Administration Irma Pavlinič-Krebs.
(At the back) EU Commissioner Janez Potočnik.

sources of energy, from materials with novel properties to the use of biological systems for information processing. One of the most strategically important areas of science is synthetic biology, which is a young discipline combining engineering approaches with an understanding of biological systems. **Synthetic biology can be described as a discipline that introduces engineering approaches for the modification and creation of new biological systems through which we can solve important problems of humanity**. It is likely that that the largest single advance in the development of synthetic biology has already occurred in our heads, when engineers asked themselves why the potential of biological systems should not be used for technological applications. Synthetic biology has the potential for a new industrial revolution similar to the revolution in electronics that occurred less than one century ago. There is hardly an area of industry in which synthetic biology could not be applied. This is the reason why the majority of developed countries consider this area to be of extreme strategic importance – as an area where new boundaries are being set and an area in which intellectual rights will have great value.

Nanotechnology cell factory

An important contributing discovery of the industrial revolution was the production of large numbers of equal products using machines replacing manual labour. Standardisation was of utmost importance for serial production, and digital technology in electronics now allows the production of large numbers of identical copies of information technology products. Electronic hardware is becoming smaller and smaller allowing a higher density of integration. Today, nanotechnology is the next challenge. Its components are of nanometer sizes, which is probably the smallest technologically accessible size. In life sciences, we have long known about the production of large numbers of identical molecules or cells, which we call cloning. In cells, we can produce drugs or enzymes that are nanometer-sized machines capable of numerous functions. The density of information in DNA is a billion times larger than currently available in the most advanced memory units.

Prof. Dr Roman Jerala giving a lecture on synthetic biology at the Slovenian national assembly.

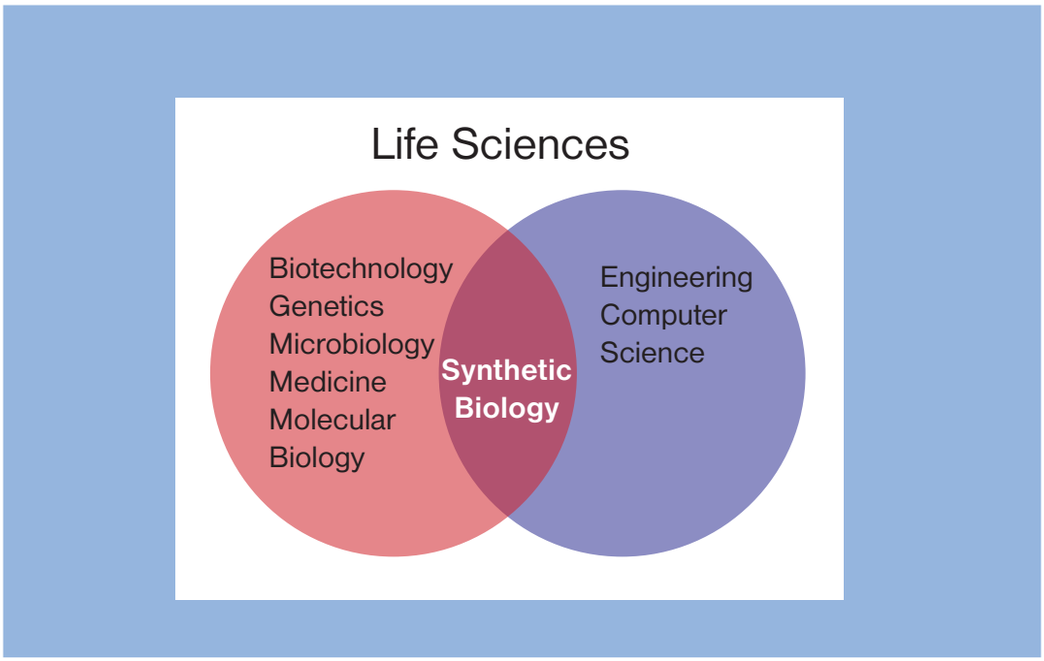
Tools that have allowed the development of synthetic biology

Synthetic biology has become possible on the basis of advancement in technologies that allow us to change biological systems to a previously unknown extent. This has been influenced by improved understanding of biological processes, such as intercellular messaging, immune response, digestion, and the creation of cellular building blocks. Today, we know the spatial structure of a large number of proteins that carry out the majority of functions in cells. On this basis, we can prepare proteins with altered properties, such as biological drugs with long-term action or enzymes that are active at higher temperatures. We have unravelled the human genome, together with the genomes of several hundreds other organisms including the majority of pathogenic and industrially important microorganisms. The newest technologies allow us to determine DNA sequences with a capacity of several billion nucleotides per week, which corresponds to the entire human genome. Meanwhile, it

is now possible to synthesise any gene sequence thousands of bases long. It is now clear that a leap is required from "boutique" solution of addressing each problem separately to standardisation that would support modular construction of devices. As with modern electronic devices, where we no longer assemble circuits from separate transistors but rather use integrated circuits with well-defined properties, gene-based devices could enable simpler and faster construction of biological machines.

Synthetic biology as a scientific discipline combining life sciences with engineering principles.

laboratories and highly trained experts making the likelihood of "garage" bioterrorism very small. The understanding of DNA as the basic building block of genetic information is now more than 50 years old and has been part of the curriculum in most schools for several decades. New discoveries in science should become part of general education in the same way as knowledge of languages, the make-up of the solar system or evolution. Only through appropriate education will we be able to use, as well as judge, the strengths and weaknesses of new technologies.



Potential dangers and public communication

As with all advanced technologies, synthetic biology brings potential dangers. Experts in the field are well aware of these and have tried to stimulate creative potentials to limit the dangerous sides of the technology through a policy of open communication with the public. Dangers such as bioterrorism are probably not increased by synthetic biology, compared with known biological agents such as viruses and bacteria, which can quickly spread due to increased global mobility as seen in the case of SARS. Companies that produce nucleotide sequences by order employ preventative analysis of ordered sequences to prevent reconstruction of dangerous viruses. Activities in this area require well-equipped

What can we expect from synthetic biology – examples Preparation of an antimalarial drug through synthetic biology

Perhaps the best-known success in synthetic biology has been the preparation of a drug against malaria – artemisinin – in microbes that are grown in industrial fermentors. Artemisinin is a recent drug against malaria that is used for treatment in areas where the causative agent of malaria is resistant to previously used drugs. The starting compound for artemisinin is a complex molecule that is obtained from Artemisia annua (annual wormwood), which can be harvested only in limited quantities. This makes the drug largely unavailable to people living in the third world, the area most affected by malaria, with 250 million cases and 1 million deaths annually. Researchers from UC Berkeley have transferred the entire biosynthetic chain for the production of the starting compound into yeast and bacteria. The task required the transfer of 50 genes, knowledge of the metabolism of the bacteria, and identification of the steps limiting the production. The yield was improved in excess of a million-fold to yield a product that was ten times cheaper than that obtained from plants. In addition, it could be produced in unlimited quantities. This achievement nicely illustrates the potential of synthetic biology for industrial processes where we can employ enzymes to produce very pure products under mild conditions, with little waste and high energy-efficiency. Of course, it is critical that we have a detailed understanding of the basic cell processes involved.

Biological materials with novel properties

Some natural materials have properties that we have not yet managed to reproduce. An example of such a material is the silk produced by spiders. Spider silk is elastic and substantially stronger than the steel or Kevlar used in bulletproof vests. At the same time, it is permeable to humidity and is not immunogenic or allergenic, and so has great potential in medicine. Unfortunately, we cannot farm spiders as can be done with silkworms, so this material has not been available for technological applications. That is until the structure of spider silk was deciphered and bacteria were used to produce a material that is almost indistinguishable from natural spider silk. Now that spider silk can be produced, it can be modified to give it new functional properties such as colour and water repellency or add enzymes that degrade dirt or have other properties.

Synthetic biology and renewable energy sources

The issue of renewable energy sources in connection with climate change is one of the most urgent problems facing humanity. Perhaps some sort of a **Manhattan Project for renewable**

energy sources could bring together the creative scientific potential. Biomass is one of the most important collectors of solar power. However, ethanol obtained from corn has been shown to be useless since, apart from other problems, the energy invested in production exceeds the energy available in the ethanol as fuel. With the use of synthetic biology, we are able to modify microorganisms so that they can convert biomass, especially cellulose, into molecules similar to conventional fuels. Fuels obtained through this route would be neutral in terms of the carbon balance if based on plants grown in currently unused areas. The multinational company BP has invested 500 million dollars in a new institute for energy biosciences (EBI) at UC Berkeley. There are now several new companies dealing with synthetic biology and studying various approaches from the use of algal photosynthesis to production of fuel from cellulose waste.

Slovenian successes in synthetic biology

Good infrastructure is important for achieving success in synthetic biology. However, even more important are original ideas, which can come only from leading experts who were students with an excellent education. In this area, Slovenia has shown some exceptional success. In synthetic biology, there is a unique global competition of student research projects that joins education and research and is organised at one of the world's leading universities. The International Genetically Engineered Machines competition (iGEM) takes place at a meeting at the Massachusetts Institute of Technology (MIT). The first competition was organised in 2004 when teams from five US universities presented their projects, which students had prepared during their summer vacation.

The Slovenian iGEM team for 2009 in front of the MIT building in Cambridge MA. The team prepared new type of bionanomaterials based on peptides and demonstrated their use for viral filtration devices, regulated assembly of biomaterials and formation of geometric structures based on peptides. Team members from left: Helena Gradišar, Jelka Pohar, Sabina Božič, Tibor Doles, Marko Verce, Ota Fekonja, Robert Bremšak, Urška Jelerič, Iva Hafner, Anja Lukana, Špela Miklavič, Nika Debeljak and Roman Jerala. The team won the gold award at the iGEM competition. Team Slovenia was also nominated for the prestigious World Technology Award, awarded by WTN in association with Time magazine, Fortune, CNN and Science/AAAS for innovations with the greatest likely long-term significance.

The following year, teams from Cambridge University in England and ETH in Switzerland joined the competition, which then became international. For comparison, let us mention that the budget of the Swiss ETH exceeds 2 billion Swiss francs, which is more than the entire Slovenian science budget. Compared with the Slovenian participants, these teams have no problems with the funds needed for preparation of the projects. By 2006, the number of competing teams had reached 37, and among them for the

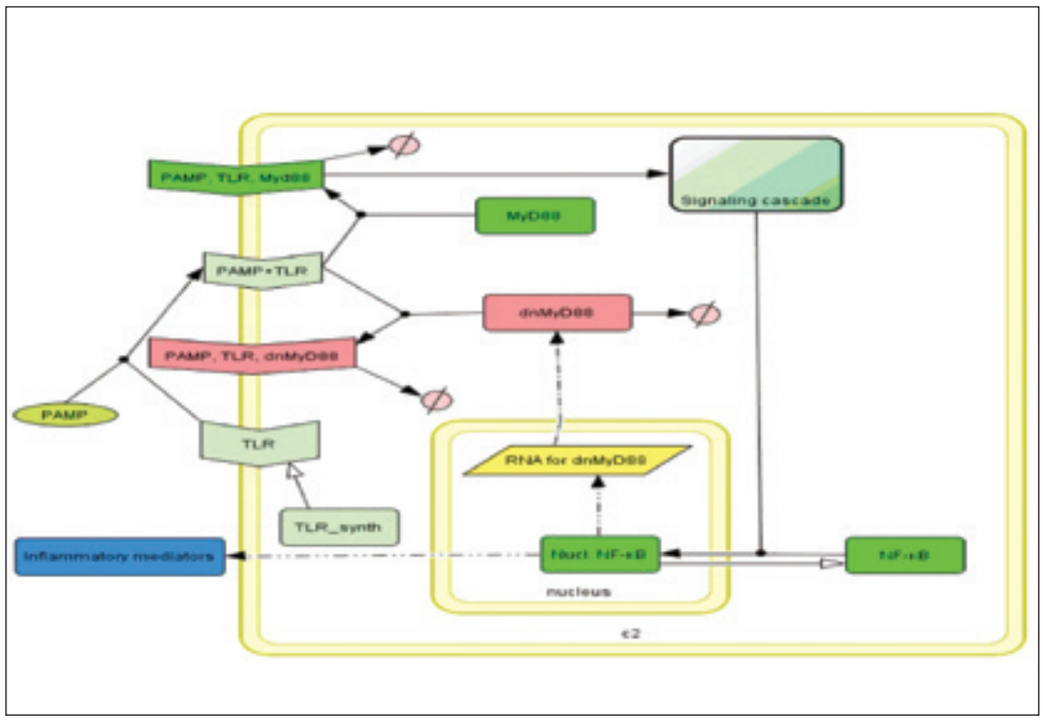
first time was a Slovenian team. The competition also became formalised with the awarding of a grand prize and prizes in specific categories. The judges were selected from professors from the most prestigious universities, editors of very respected journals, as well as researchers from biotechnology and pharmaceutical companies. The Slovenian team consisted of students from the natural sciences faculties that performed their research work at the National Institute of Chemistry under the mentorship of researchers from the National Institute of Chemistry and the Faculty of Chemistry and Chemical Technology of the University of Ljubljana.

The 2006 project: reducing the exaggerated immune response

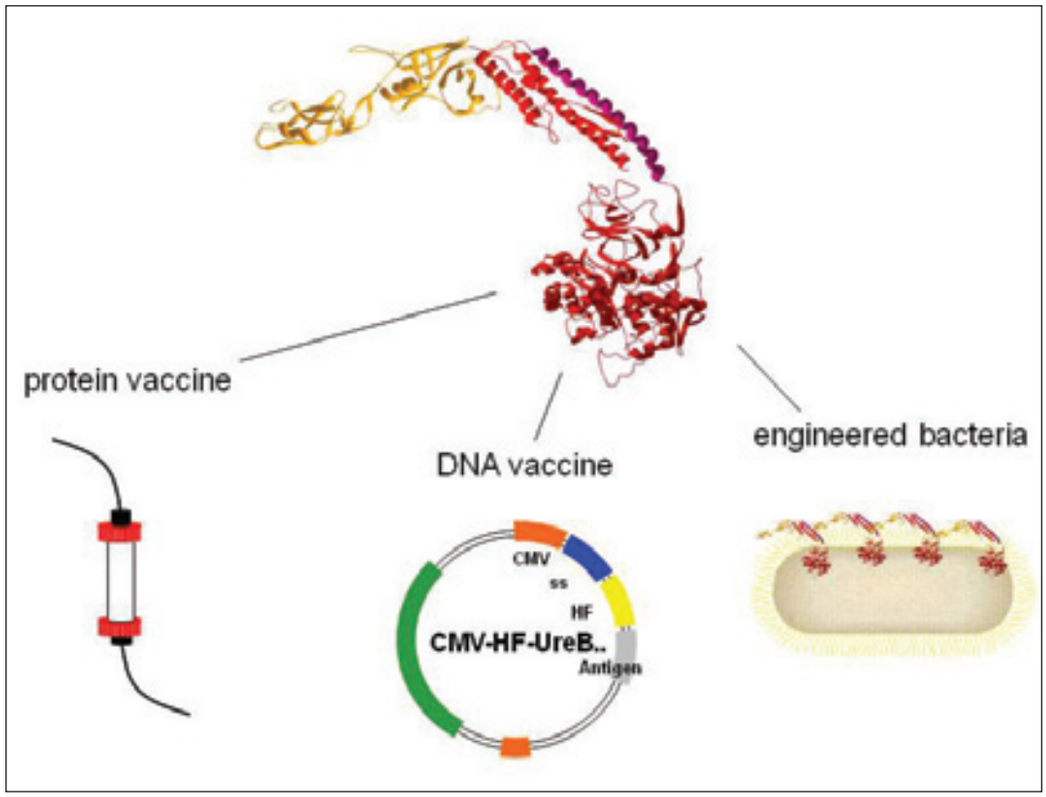
During the entry of bacteria into the human body, an immune response is triggered which protects the organism from pathogenic microorganisms. During sepsis, the response of the organism is over-exaggerated so that even with the use of antibiotics, organ failure often occurs and the result can be death. Within the EU, this complication leads to 200,000 deaths each year. The goal of the research project was to modify the cellular response so that it is still on but shuts down if an over-exaggerated response occurs. This was achieved by introducing a feedback loop. In its first presentation, the Slovenian team was very successful and was entered into the finals together with teams from two highly respected universities, Princeton and Imperial College. In the end, the Slovenian team achieved first place, the grand prize and several trophies in specific categories.

The 2007 project: a genetic device to combat HIV viral infections that is not sensitive to viral mutations

In 2007, we set ourselves the goal of preparing a system that recognises an infection with the HIV virus regardless of viral mutations. Rapid mutations of the virus are responsible for the resistance of the virus to a number of drugs



Schematic representation of an engineered negative-feedback loop designed to suppress excessive activation of immune response that may lead to sepsis.



Vaccine designed for use against Helicobacter pylori based on fusion with flagellin and urease B. Three implementations of the vaccine are shown.

and the fact that an effective vaccine is still not available. The original idea of our project was to link recognition of the virus to an important viral function, rather than to a specific protein that can be changed by mutations. We were able to give a proof of concept for this very demanding project. In five months of work, the students prepared more than 70 gene constructs and used the most advanced techniques available in Slovenia. With this project, the Slovenian team again reached the finals, received a gold medal and was judged as the best project in the area of medicine and health. The webpage of the project has to date been visited by18,000 visitors from 78 countries.

The 2008 project: preparation of a synthetic vaccine against the bacteria causing ulcers and stomach cancer

In 2008, we decided to carry out a project leading to results that can be applied in practice more rapidly. We selected preparation of a synthetic vaccine against the Helicobacter pylori bacteria that causes stomach ulcerations and eventually stomach cancer. The bacteria has adapted to the human immune system and has changed its components so that immune system receptors cannot detect it. Among these components is the protein flagellin that is part of the flagellum, which the bacteria needs to survive in the stomach. We have made flagellin visible to the immune system by creating a hybrid protein – a combination of flagellin from bacteria that are detected by the immune system and flagellin from Helicobacter bacteria. Additionally, we added several segments needed for bacterial survival to the protein that was used in the vaccine. We prepared three different variations of the vaccine and tested the functioning of the principle in cells, as well as showing an immune response in an animal model. The judges gave this original approach and the experimental execution very good marks, so that the team achieved a unique third placement in a row in the finals. The project was chosen as the best in the area of medicine and health and was awarded the grand prize in the general competition. The toughness of the competition can be seen from the fact that eight of the ten best universities participated, including Harvard, Cambridge, Stanford, Princeton, ETH, UC Berkeley, Caltech, etc.

Future development of synthetic biology in Slovenia

These successful projects have confirmed the general correctness of the ideas. However, to reach final scientific results and practically useful results, more scientific study is required. The winning teams and members of the laboratory at the National Institute of Chemistry continue their work in these areas. With our successes, we have been able to show that, through motivation and the knowledge of students and mentors in the field of synthetic biology, we can compete on an equal basis with the best in the world.

Slovenia is a country with limited potential in financial resources as well as in people. It is thus important to create conditions for young talented students to develop their potentials in Slovenia and use their creativity to contribute to the success of Slovenia in a globalised world. As we are selecting candidates for this year's competition, we again see that we have received applications from a number of excellent and motivated candidates, despite their realisation of just how much hard work will be needed for the project and the fact that scientific successes are not always on a par with sports or entertainment in the public eye or in the political world.

Members of the Slovenian iGEM team for 2008 in front of the National Institute of Chemistry. Their project was selected as the best in the health and medicine section and won the Grand Prize. Team members: Simon Horvat, Eva Čeh, Jan Lonzarič, Ana Lasič, Jerneja Mori, Nina Pirher, Vid Kočar, Monika Ciglič, Katja Kolar, Karolina Ivičak, Anže Smole, Roman Jerala.

The National Assembly

Lecture title:

"From Here to Eternity"

Elementary Particle Physics and its Impact on Society

Lecturer: Dr P. Križan

Introduction

Nature is organised in levels; from galactic clusters in the Universe, our solar system and the Earth, all the way down to atoms, atomic nuclei, nucleons and finally quarks. The different levels differ dramatically in the size of objects and in the forces that operate between them. While the motion of galaxies, stars and planets is determined by the gravitational force, and while electrons are bound to nuclei by the electromagnetic force, it is the strong and the weak forces that dominate among quarks.

It is perhaps surprising that a connection exists between the lowest level i.e. the physics of elementary particles, which represents one 'infinity', and the other 'infinity', which is the large-scale structure of the Universe. This connection is a consequence of the link between elementary particle physics and the early universe. The early universe was very dense and very hot (in the same way as hot gas is compressed in the cylinder of an automobile motor). In a gas at high temperature, particle velocities are high, so the collisions of particles in the early universe resembled the collisions in today's accelerators. This similarity is true also for the various processes among the particles.

The Standard Model of elementary particles

We have two requirements of any description of the basic constituents of matter. The description has to be simple, with a small number of elementary particles, and it has to be consistent with reality. In the sixth century BC, Anaximenes of Miletus hypothesised that nature is built of four elements: air, fire, water and earth. No doubt this is a simple model, but it does not correspond with reality. On the other hand, Mendeleev's periodic system contains about one hundred elements. Although this is a true description of nature, it is by no means a simple one.

A lot has happened in science since Mendeleev's work. The current description of elementary particles and their forces, known as the Standard Model, is an unbelievably successful, experimentally verified theory. According to this theory, we have 12 elementary particles, including electrons and u and d quarks, which are constituents of protons and neutrons, which in turn are constituents of atomic nuclei. Each particle has its antiparticle; a positron corresponds to an electron, an antiquark to a quark. We cannot find anti-

particles in nature, but we can produce them with accelerators. In addition to these particles, we have force carriers, which we may think of as a kind of projectiles, exchanged by elementary particles. There is also the hypothetical Higgs particle, which is theorised to be responsible for the fact that elementary particles have different masses.

CP symmetry and its violation

One of the big questions regarding today's Universe has to do with antiparticles. In the instant of creation, the Universe consisted of equal numbers of particles and antiparticles. Today, the Universe consists almost exclusively of matter and not of antimatter. In 1967, the Russian physicist Andrei Sakharov published a theory that explained the evolution of the Universe. One of the key elements in his explanation is the small difference in the decay rate of particles and that of antiparticles.

This difference is attributed to the violation of a symmetry, called CP symmetry, between particles and antiparticles. The first case of violation of this symmetry was observed in 1964 by a team led by the American physicists Val Logsdon Fitch and James Watson Cronin. In 1973, two Japanese theoretical physicists, Makoto Kobayashi and Toshihide Maskawa, have proposed that such a difference could be explained if six, instead of only three, quarks existed. They even predicted that in the future it would be possible to measure the difference between decay rates of particles and antiparticles composed of these new quarks.

Lecturer:
Dr P. Križan

Measurement of CP symmetry violation

During the eleven years following the publication of their theory, physicists have discovered all three missing quarks. The main proof of CP-symmetry violation among these particles, however, did not arrive until the beginning of this decade, when the Belle and BaBar experiments, taking data at accelerators in Tsukuba in Japan and Stanford in California, discovered just such a violation. These experiments measured a small difference between decay rates of particles and antiparticles, consisting of the quarks predicted by the two Japanese theoreticians. The demanding measurements of this particle decay, with a life-time of only one trillionth of a second, confirmed their predictions. According to the Nobel Committee, this experimental confirmation was crucial in last year's decision to award the Nobel Prize in Physics to Kobayashi and Maskawa.

An important contribution to the confirmation of the Kobayashi-Maskawa theory was made by Slovenian physicists from the Jožef Stefan Institute and the universities of Ljubljana, Maribor and Nova Gorica (Fig.1). Our group of physicists participated in the Belle experiment at the Japanese KEK institute, where Kobayashi did his research. The experiment is typical of elementary particle physics. Electrons, as well as their antiparticles positrons, were accelerated in the KEKB accelerator, where they collided in the centre of the spectrometer. The collision produced heavier particles, called B mesons, and their antiparticles, anti-B mesons. These are both unstable and decay into lighter particles in about one trillionth of a second. In the experiment, we searched for differences in these decay modes, because such differences point to the violation of CP symmetry between particles and antiparticles. It may be worth mentioning that the accelerator in which we accelerated these particles uses electromagnetic waves with a frequency similar to the frequency of waves used by cell phones. The Belle detector is full of original technical solutions as well as advanced technology.

The result of the most important experiment is shown in Fig. 2. The time dependence of anti-B meson decay is shown with blue dots and blue curve,

whereas the same is shown in red for B mesons. From the difference in the time dependence of B and anti-B decay rates, it is obvious that CP symmetry is violated. The difference between the rates for particles and antiparticles is in agreement with the predictions of Kobayashi and Maskawa, confirming not only their hypothesis, but the Standard Model as well.

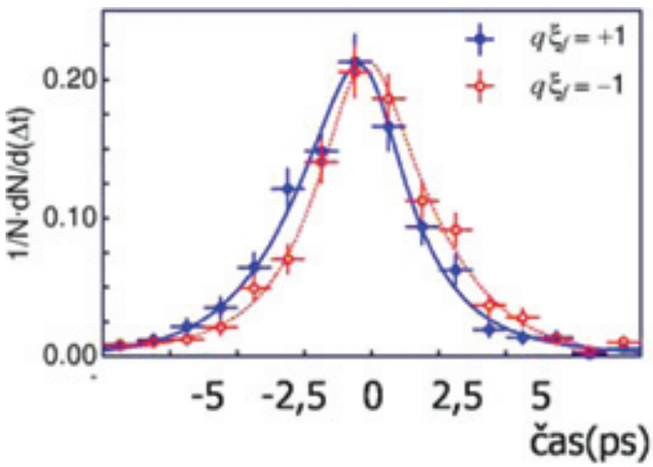
Future goals

The next big goal for particle physics is to prove the existence of the Higgs particle, the only missing stone in the mosaic of the Standard Model. This particle is essential , since it explains the different masses of the particles within the Standard Model. The hunt for the Higgs particle is the task of experiments at the Large Hadron Collider (LHC) in Geneva, for which ATLAS is the largest detector. Within ATLAS, the Slovenian team led by Marko Mikuž is one of the groups.

Will physics end with the discovery of the Higgs particle? In other words: Is the Standard Model the final theory of elementary particles and their interactions? There are indications that it is not. Firstly, the system of 12 elementary particles and as many antiparticles, three interactions and force carriers, and on top a particle to give mass to all the others, is quite large and resembles the unwieldy system of elements. Even more obvious is the fact that normal matter in the Universe is six times less abundant than so-called "dark matter", which, on the basis of its influence on the motion of galaxies, is known to exist, although it is not known what kind of particles it is made of. In addition, the difference between matter and antimatter is much larger than the difference measured in B-meson decays contained in the Standard Model. Also, deeper theoretical arguments suggest that the Standard Model is only a successful description of processes in the world of elementary particles, but is not a truly fundamental theory.

For such reasons, several groups are searching for deviations from the Standard Model, which is otherwise very accurately verified. Two possibilities exist for such investigations. One is the direct search for new particles at the highest attainable energies i.e. at the LHC collider. The second possibility is to search for small deviations from the expected characteristic processes, as for example in the decay of B mesons. These extremely accurate measurements can be performed at lower energies. The two methods are complementary as they investigate different aspects of the same problem.

The latter research method will be used by our group. The first step has already proved successful. In B-meson decay, into two lighter particles called a kaon and a pion, we have discovered an obvious inconsistency, which is sufficiently interesting that we have published it in the prestigious journal Nature. This, however, does not mean that we have discovered particles outside of the Standard Model, but together with some other measurements, it offers a hint in that direction.



Measured difference between the behaviour of particles (in blue) and antiparticles (in red).

The only answer to open questions is to substantially improve measurements, in their accuracy as well as the size of the sample. This is the aim of the Belle-II project, for which we expect the accelerator and the detector to be ready by 2013. The Slovenian group is among the leaders of the project and our researchers hold some key positions. We expect that Slovenian industry will remain an important contributor in the search for technological solutions as well as a supplier of equipment for this most advanced project.

The importance of basic research

Why basic research? The search for answers to questions about the world around us is an essential part of mankind, without which our civilisation would not exist. Slovenia must contribute its share to the world fund of knowledge and so be recognised as an equal participant. Ours is certainly a small nation, and it is therefore not possible to excel everywhere. However, if our expertise in a certain area is above average, it is worth continuing work, to "bet on a winning horse". We should be aware that we are too small and not sufficiently wealthy to do anything but first-class research. The above-mentioned projects, the Belle experiment as the most recognised experiment of the past decade, LHC as the largest scientific project in human history and Belle-II as the most accurate experiment of the next decade, surely belong in this category.

The dilemma of the usefulness of basic research is quite old, as exemplified by the following anecdote. The English physicist Michael Faraday (1791–1867) discovered magnetic induction, which in his time was considered as pure or basic research. Today, it is not possible to imagine normal life without magnetic induction, since it is the foundation of radio, television, mobile telephones and computers. When asked, by the current finance minister, of what use were his investigations of magnetic induction, Faraday is supposed to have replied: "Although I do not yet know of what use my research will be, I am sure that the successor of the finance minister will be collecting taxes from its applications."

Some well-known consequences of basic research, without which our life would be very much different, are worth mentioning. When the earliest known of today's elementary particles (the electron) was discovered, nobody could imagine the impact this discovery would have on everyday life. The transistor was discovered more or less by chance, while investigating semiconductor diodes, and the laser was discovered while searching for an intense source of light for the needs of basic science. The protocols for the World Wide Web were developed in the European Laboratory for Particle Physics (CERN), in order to allow efficient computer connection, despite the geographical separation among members of large international collaborations.

In addition to the unpredictable results of basic research, there also exists direct consequences, among which education and training of young scientists and engineers seems to be the most important contribution to the growth of the economy.
Concerning the transfer of knowledge in physics of elementary particles, we

M. Kobayashi and some of the members of the Slovenian team in the Belle experiment (from left B. Golob, R. Pestotnik, S. Korpar, P. Križan, M. Kobayashi, M. Starič).

should give special mention to development of new methods for health care, protection of the environment and to the development of telecommunications. As an example, let me present possible improvements to medical diagnostic imaging, where a veritable revolution may follow due to detectors that have been developed for experiments in elementary particle physics. Positron emission tomography (PET) is a diagnostic technique in which a substance, labelled with radioactive fluorine, is injected into the patient's vascular system. Upon radioactive decay of fluorine, two back-to-back gamma rays are created. At locations where more of the radioactive substance is concentrated, e.g. in a tumour, more gamma pairs will be created. There, gamma pairs are detected with a combination of scintillation crystals and light detectors. The standard detector of light is the photomultiplier, which is an evacuated glass vessel, about 10cm long, and is quite sensitive to external magnetic fields. In elementary particle research, a new light sensor has been developed, the so-called silicon photomultiplier, which is not only very much smaller (a few millimetres), but has the excellent property of also being efficient in quite large magnetic fields. The use of such detectors would not only enable more compact PET systems, but would allow simultaneous imaging with two modalities: magnetic resonance imaging (MRI) and PET. Due to the complementarities of the two modalities, this would represent a true advancement in efficient diagnostics.

In technology transfer, we should also mention the development of the technology for the manufacture of flexible printed circuits on laminated aluminium-kapton foils. This was a joint enterprise of researchers from the Jožef Stefan Institute, the ELGO-LINE company from Cerknica, Balder d.o.o. from Ljubljana, FDS Research from Trzin and Apel d.o.o. from Ljubljana. In collaboration with our researchers, the ELGO-LINE company has developed a production line for the circuits required for the ATLAS spectrometer. This project is worth about USD 1 million for Slovenian companies. The experience with the new technology will allow ELGO-LINE to sell this new product also to other customers. Use has been made of the fact that this technology enables the manufacture of thin surface heaters, which represents a new product and an interesting marketing possibility for ELGO-LINE.

Another example of technology transfer should be mentioned. As with the World Wide Web, which originated from elementary particle physics, we are now witnessing a new revolution. Due to the necessity of connecting computer systems for processing of the large quantities of data that will be obtained in future high-energy physics experiments, scientists have developed the GRID concept, as the next step in the evolution of the Internet. This is the forerunner of the "plug-in computer", which would be available in every household. The Large Hadron Collider is the first user of this system. Slovenian physicists are actively participating in this network. At the Jožef Stefan Institute, a section of the GRID has been set up, named SIGNET. The Slovenian part of the system includes 500 processors and 170 TBy of memory, all of which are available for research.

Conclusion

The physics of elementary particles is a very active science about the smallest and the largest scales of the Universe, simultaneously well anchored in everyday life. Slovenian physicists are in the front line of the search for answers to the questions now being posed in physics and related interdisciplinary fields. The indirect results of our research are applications of new technologies and progress in medical imaging and protection of the environment.

The National Assembly

Lecture title: "Ultra-High Energy Cosmic Rays – Slovenian Scientists at the Crossroads Between the Infinitely Small and Extremely Large"

Prof. dr Samo Stanič
Lecturer: Prof. Dr Danilo Zavrtanik

Abstract

The existence of ultra-high energy cosmic rays, or UHECR, is one of the most intriguing experimental observations of contemporary physics. We know they exist, but cannot as yet either identify their sources or determine their identities. Since they are very scarce (at the highest energies, less than one particle per millennium hits a square kilometre of the Earth's surface), their detection represents a huge experimental challenge. To meet it, a vast UHECR observatory covering an area of 3,000 square kilometres was built in Argentina by an international research collaboration named after the pioneer in the field of cosmic rays, Pierre Auger. Slovenian scientists have been taking part in the design, construction and use of the observatory since the initial project was proposed.

Lecturer: Prof. Dr Danilo Zavrtanik, director, the University of Nova Gorica

Introduction

Over the past decades, progress in the field of accelerator-based elementary particle research has been stunning, and today, with the commencement of the operation of the world's largest collider, the LHC at CERN, many physicists hope that most of the remaining open issues concerning elementary particles will soon be resolved.

Research in astrophysics, however, indicates that the elementary particles we have investigated and continue to investigate in such detail within particle accelerators constitute only a small part of the matter in the universe around us. It appears that so-called "dark matter", which we know practically nothing about, governs a number of processes in the universe, from the mechanics of galaxy motion to the expansion rate of the universe itself. The existence of subatomic particles with extremely high kinetic energies (one billion times higher than those of the protons created in the LHC) that hit the surface of our Earth is another intriguing fact. Research into these phenomena combines elementary particle physics with cosmology and

is one of the reasons for joining these research efforts into a new field of science, known as astroparticle physics, which is one of the real challenges for the future. Slovenian scientists from the University of Nova Gorica and the Jožef Stefan Institute in Ljubljana are among the pioneers in this exciting new field.

Ultra-High Energy Cosmic Rays

Under the term "cosmic rays", one generally assumes all kinds of ionising subatomic particles arriving at the Earth from space. It is fascinating that these are far from uniform in either their type or their energy; their energy spectrum extends over eleven orders of magnitude, while their flux at different energies extends thirty orders of magnitude. Of particular interest is the existence of ultra-high energy cosmic rays (UHECR), with energies above 10^{19} eV, which is one of the most intriguing experimental observations of contemporary physics. To illustrate this fact, the kinetic energy of a single subatomic particle – UHECR at the very highest energies – is comparable to the kinetic energy of a 7g bullet fired from a pistol.

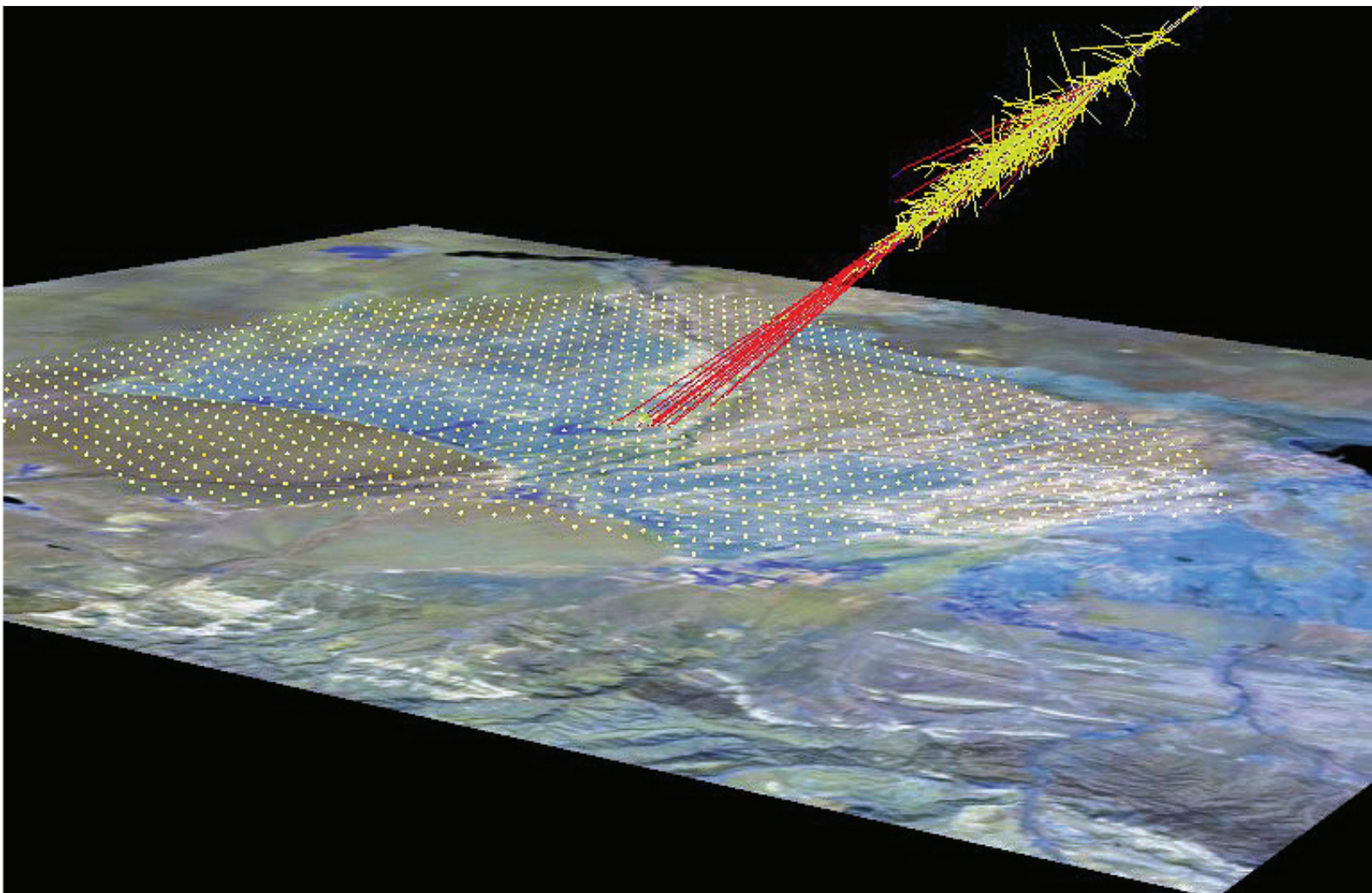
Combining the Standard model of elementary particles and the astrophysical properties of the known astronomical objects in the universe, such high-energy particles are very unlikely to exist, and yet several experiments have demonstrated that they do. Given the current understanding of nature, ultra-high energies could only be achieved in as yet poorly understood objects and processes in space such as black holes, active galactic nuclei or Supernova shockwaves, which are thought to act like giant particle accelerators. If cosmic rays with the highest energies are predominantly protons or nuclei, only sources closer than 6.5 million light years from the Earth can contribute appreciably to the observed flux of cosmic rays. Protons and nuclei with energies above 6 10^{19} eV interact with the cosmic microwave background, leading to strong attenuation of their flux from more distant sources. The major problem is that there is only a very limited number of source candidates within the range that still enables UHECR to reach the Earth. Therefore, it is possible that the UHECR are a product of interactions between some as yet unknown elementary particles, at energies inaccessible by man-made particle accelerators, which may have existed in the first moments of the Big Bang.

Figure 1: Computer simulation of a cosmic ray air shower development above the southern site of the Pierre Auger Observatory in Argentina. This shower was caused by collisions between an incident proton with energy of 10^{19} eV and air molecules at an altitude of about 20 km above the Earth's surface. The dots on the surface represent ground detectors of the observatory.

Understanding of cosmic rays with the highest energies is still at a very basic level. Until now, five experimental collaborations have measured their energy spectrum, but due to the systematic uncertainties and low statistics, their results exhibit considerable discrepancies. Since UHECR are very scarce (at the highest energies, above 10^{20} eV, only several particles per millennium hit a square kilometre of the Earth's surface), their detection represents a huge experimental challenge. To clarify these unknowns, a group of scientists, led by the Nobel laureate James Watson Cronin, began an international collaboration in 1995 named after the pioneer in the field of cosmic rays, Pierre Auger, and constructed a new observatory of gigantic proportions, entirely dedicated to the detection of UHECR at the highest energies.

The Pierre Auger Observatory

Several questions regarding UHECR at the highest energies have already been answered thanks to the endeavours of the Pierre Auger Collaboration. Because of their extremely low flux, UHECR can only be detected through their interaction with the Earth's atmosphere. As they enter the atmosphere,



they collide with air molecules and create extensive air showers of charged energetic particles that almost simultaneously hit the ground, covering an area of tens of square kilometres. Using a grid of 1,660 ground-based cosmic ray detectors and 24 telescopes for the detection of fluorescence – components that constitute the southern site of the Pierre Auger Observatory in Argentina, stretching over some 3,000 square kilometres – the observatory can measure the incoming directions, rates and energies of detected UHECR.

Ground detectors, which measure the two-dimensional lateral structure of the shower at ground level, are simple and robust water-Cherenkov counters deployed over the Pampa Amarilla plateau in the Argentinean province of Mendoza. Their required lifetime is at least 15 years, matching the expected time span of the experiment. On the other hand, fluorescence detectors are sophisticated UV cameras that record the longitudinal profile of the shower during its development through the atmosphere and are positioned in four dedicated buildings at the edges of the detector array. For measurement of the air showers, precise and prompt understanding of atmospheric conditions from the ground level to an altitude of several tens of kilometres is mandatory. For this purpose, dedicated light detection and ranging (LIDAR) systems that continuously monitor the atmosphere above the observatory have been developed. These devices were designed and built in Slovenia and later deployed to the observatory site in Argentina.

One of the lidars developed remained in Slovenia and was placed at the University of Nova Gorica Observatory for Atmospheric Research at Otlica above Ajdovščina. The observatory, including all of its equipment, was built as a result of the knowledge gained throughout the research and development of Slovenian scientists involved in the Pierre Auger collaboration. The lidar is now used by the researchers of the University of Nova Gorica and the Environmental Agency of the Republic of Slovenia to monitor transport processes in the planetary boundary layer at the land-sea transition zone between the Adriatic Sea and the observatory site.

"Overhead view of the Pierre Auger Observatory superimposed on the map of Slovenia. The smaller contour represents its southern site in Argentina, completed in 2008, and the larger one, its proposed northern site to be built in Colorado, United States."

The southern site of the Pierre Auger Observatory in Argentina was completed and inaugurated in 2008. The Pierre Auger Collaboration has been, from its very beginning, an international scientific enterprise, and at present consists of more than 450 researchers, technicians and PhD students from 17 countries around the world, including Slovenia. As an example of true partnership, the southern site of the observatory was constructed on the basis of financial and intellectual contributions from all member states, with every country contributing approximately its proportional share. Slovenia, as a very small country (about the same in size as the area of the proposed northern site of the observatory in Colorado and with a population of only two million), covered the majority of the funding costs for the construction of the lidar sites in Argentina. As participating scientists, we are proud to have incorporated Slovenian knowledge into this truly international project.

First Results

The most important result of the Pierre Auger collaboration to date is the discovery of a high-energy cut-off in the UHECR energy spectrum, which implies that, along their path, UHECR loses energy through interactions with the microwave cosmic background.

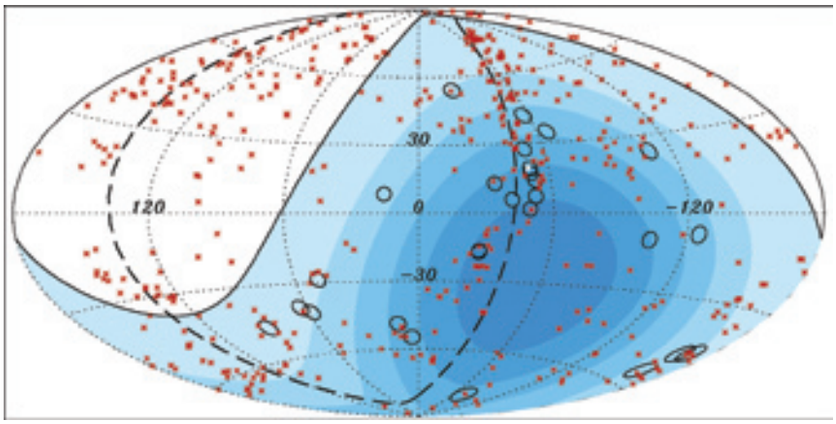


Figure 3: Aitoff projection of the celestial sphere in galactic co-ordinates with circles centred at the arrival directions of the 27 cosmic rays with highest energy detected by the Pierre Auger Observatory and the positions of the active galactic nuclei (AGN) marked by red asterisks. Centaurus A, one of the closest AGN, is marked in white. The first results, which are still inconclusive, support the hypothesis that the AGN of the nearby galaxies may be the sources of UHECR.

This indicates that, in order for UHECR to be able to reach us, their sources must be relatively close to us. The second important result is that the extreme energy cosmic rays are much rarer than originally anticipated – less than one of these extreme energy cosmic rays hits one square kilometre of the Earth's surface during a period of 1,000 years. The scientists of the collaboration are at present trying to pinpoint their astronomical sources – which must be nearby – and to subsequently provide an answer to fundamental questions as to what drives UHECR to such enormous energies, as well as to determine how to classify UHECR in terms of the known elementary particles. Using the southern site of the observatory, we can record some 25 UHECR events per year with energies sufficiently high for study of the anisotropy of their incoming directions. This number is rather low, making it difficult to unambiguously determine the sources of UHECR even over the entire lifetime of the experiment. The first results, supporting the hypothesis that the active galactic nuclei of the nearby galaxies may be the UHECR sources, were published as a cover story in the journal Science in November 2007, but they are still very far from being conclusive. Identification of the sources of UHECR is the very key to understanding their composition and an enormous step towards probing the properties of hadronic interactions at extreme energies. The proposed construction of the northern site of the observatory, potentially increasing the amount of experimental data tenfold, is definitely a step towards this goal.

Future Plans

As cosmic rays at extreme energies are much scarcer than originally anticipated, an even larger observatory than the present one in Argentina would be needed for precision measurements at the highest energies. Although the southern site of the Pierre Auger observatory will be operational for the next 15 years, and is bound to be improved and extended, designs have already been drawn up for a detector array seven times as large, covering an area of around 20,000 km^2 (roughly the size of Slovenia). The proposed location of the northern site of the observatory is in Colorado, United States. The northern site will employ the latest, state-of-the-art technologies, including shower detection using radio waves, currently under development at the southern site. The designs are based on solid scientific motives and a carefully planned budget. The members of the Pierre Auger Collaboration believe that construction of the northern site of the observatory as a joint effort is a realistic goal towards reaching more conclusive answers to the intriguing questions raised by discovery of UHECR.

Observatory for atmospheric research at Otlica above Ajdovščina, run by the University of Nova Gorica, is a direct spin-off of the research conducted within the Pierre Auger Collaboration. One of the elastic scattering lidar systems developed for the UHECR observatory in Argentina is used for monitoring transport processes in the planetary boundary layer at the land-sea transition zone and adjacent mountainous region between the Adriatic coast and the observatory site.

The southern site of the Pierre Auger Observatory uses two types of detectors to measure the properties of the extensive air showers of charged particles caused by incident ultra-high energy cosmic rays. A grid of water-Cherenkov counters (one of which can be seen in the foreground of the above photograph) measures the two-dimensional lateral structure of the shower at ground level while UV cameras (four of them are positioned in the building in the back of the photograph) record the longitudinal profile of the shower during its development through the atmosphere.

Conclusions

To conclude, it is my personal belief that basic research – the gaining of in-depth knowledge of processes in nature that we do not yet understand – is a very important task, which has, throughout human existence, always led to the greatest advances for humankind. In the case of the particles with extreme energies that bombard our Earth, the Pierre Auger Collaboration has to date successfully constructed and operated its observatory, and shed some light on the possible nature and sources of UHECR. The collaboration's plans to construct the northern site of the observatory is another step towards reaching more conclusive answers and obtaining full-sky coverage. We, as researchers, are happy and proud that a small country like Slovenia can and does participate in and contribute to large international projects like the Pierre Auger Collaboration. For us personally, as well as for the entire country, this collaboration represents an open door to the global pool of knowledge, created at the very forefront of global understanding of the world around us – with much greater import than small projects on a national level. I would like to use this opportunity to thank the Government of the Republic of Slovenia for its understanding of the importance of the international exchange of knowledge and ideas and to encourage its further activities towards joining international institutions and collaborations, and exploiting their advantages in all fields of science.

The National Assembly

Lecture title: "Nanotechnology: From Science Fiction to Wood Coatings"

Lecturer: Prof. Dr Dragan Mihailović

Nanotechnology is a field in which physicists, chemists, biologists, engineers, doctors and other researchers combine their knowledge, imagination and creativity on the level of single atoms or molecules. With the rapid development of nanotechnology and nanomaterials in the last few years, we are making significant scientific and technological progress. Slovenian scientists have eagerly responded to this challenge and some of their achievements on discovering new nanomaterials and phenomena related to them, along with their usage in different fields will be presented in this paper.

Not too long ago, even many scientists did not really understand the nature of nanotechnology. One nanometer equals 10^{-9} m, which is on the scale of a molecule. So, we can understand nanotechnology as a field that deals with matter on the molecular and atomic scale.

The field of nanotechnology is evolving so rapidly that we can discuss things today which seemed like science fiction just a few years ago. For example, scientists have been able to construct electric switches using single molecules, or computer memory based on single atoms. In electronics, we soon expect a deadlock in the miniaturisation of circuits. As the size of the elements becomes comparable to the size of single atoms, current technology will not be able to progress. Therefore, we need new approaches to computer science to help meet our demands for increasing computing performance. Quantum computing offers us completely new approaches to handle information with a small number of quantum memory elements.

However, nanotechnology is not only restricted to electronics. The largest share deals with research and synthesis of completely new substances and materials, which can then be used for different applications. Prototypes of industrially important materials include nanotubes and nanowires of different kinds, nanoparticles and biological molecules. Our ability to manipulate matter on the atomic or molecular scale is still in its early stages, but the use of nanomaterials is widespread. One such example is the range of wood coatings from Helios, which apply nanoparticles for UV and bacteria protection. Similarly, in the automobile industry, nanoparticles in a special anti-abrasive layers are used to help defects in varnish to heal automatically.

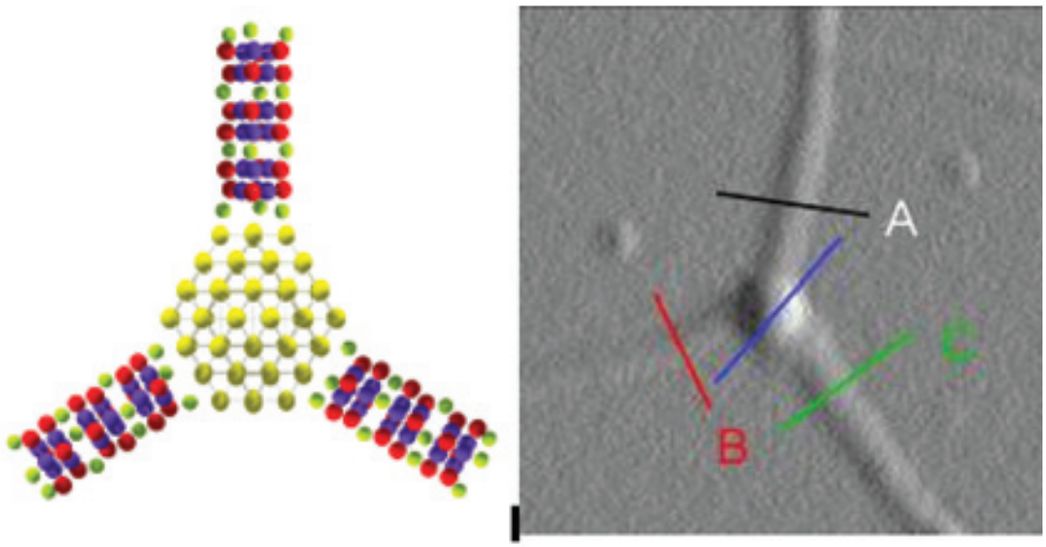
Groups from Kolektor's Nanotesla Institute, the Jožef Stefan Institute and the Institute of Oncology Ljubljana are doing research on magnetic nanoparticles that can perform as a kind of nano-robot in the bloodstream and can be used for detection of tumours, and potentially also in their healing. An interesting case of a new nanomaterial that found immediate use is MoSI nanowires, which were discovered by scientists at the Jožef Stefan institute. They can be used as additives in composites and coatings. We are also exploring their use in biological nanosensors and an "electric nose".

Each such application requires a huge amount of hard work to be brought to a commercial end. For this to happen, we need to find resources and have the appropriate equipment and infrastructure at our disposal. That led us to the establishment of the Centre of excellence in Nanoscience and nanotechnology (NiN) in 2004, which was also joined by a significant number of

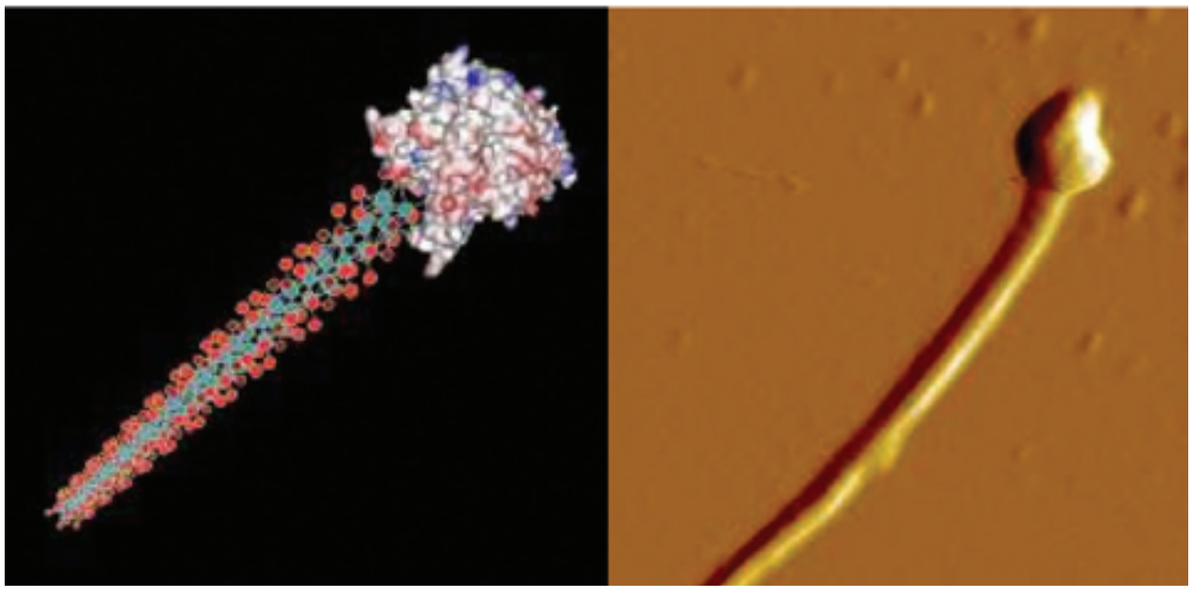
Lecturer Prof. Dr Dragan Mihailović

Slovenian companies (more information on http://nin.ijs.si). Since then, the interest in cooperation has been increasing, with more and more concrete and demanding projects in the field of nanotechnology.

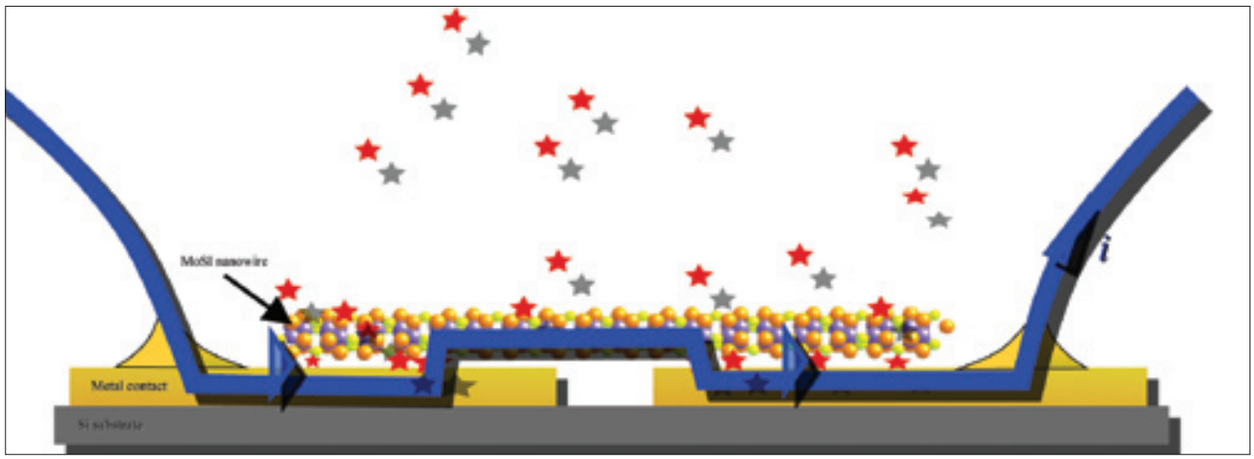
The European Commission Report for 2004 states that Slovenia ranks seventh in the world in number of publications per capita in the field of nanotechnology, ahead of Japan and the United Kingdom. This surprising result motivated us to continue work in this field, and the first commercial results are now becoming evident. The project in nanoelectronics that was carried out in partnership between groups from IJS and the company LPKF as a part of NiN has even made the finals in the REGIOSTARS competition, organised by the European Commission. The aim of the project was to develop electronic lithography using regional development funds. The challenge



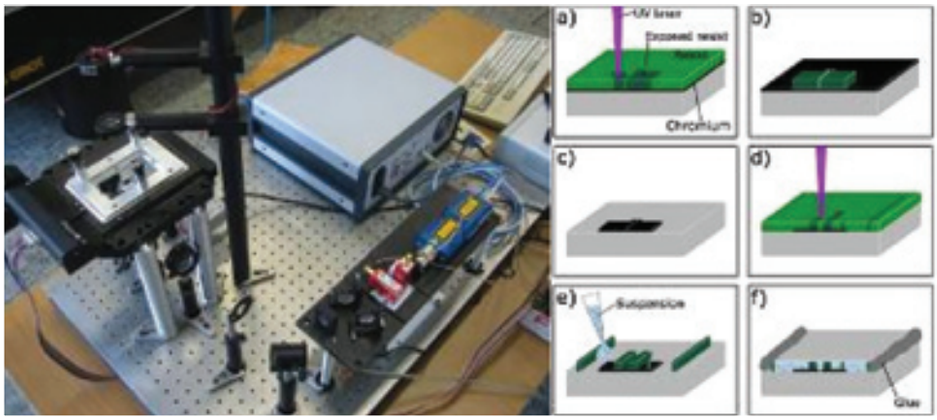
Three MoSI nanowires of 1 nm diameter are connected to a golden nanoparticle of 5 nm diameter. (Ploscaru I. M. et al., Nanoletters, 2007, 7(6)



Triglobuline molecule at the end of MoSI molecular nanowire. Image was taken by atomic force microscope.
(Figure 1: Mihailović D., Presentation)
(Figure 2: Ploscaru I. M., Doctoral thesis, Ljubljana, 2008)



MoSI-based tunneling sensor. The electric current through the circuit depends on the molecules at contacts.
(Berčič et al., Chem.Mat. 2008, 20(5))



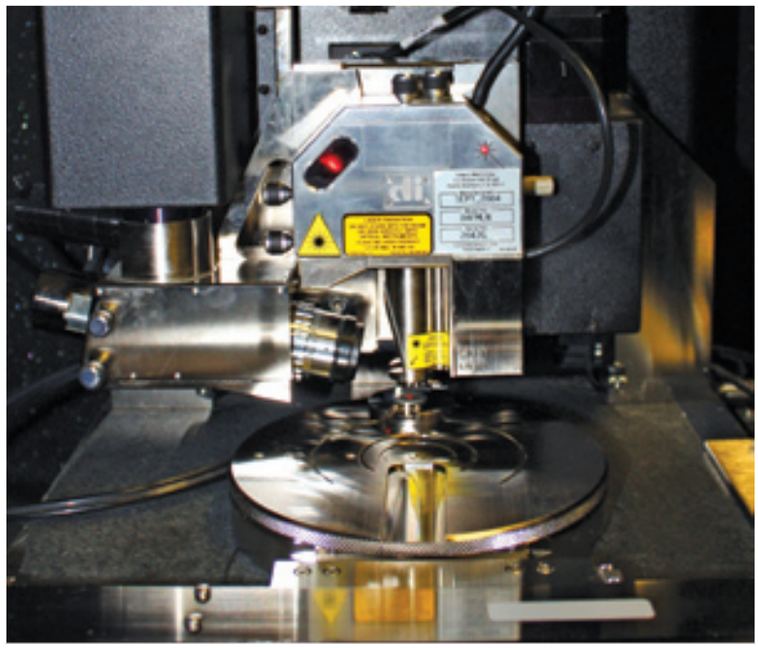
Optical nanolitography system.
(Babič D., Poberaj I. (FMF, Aresis), Kavčič B. (FMF, LPKF), Osterman N. (FMF, JSI), Podobnik B. (LPKF))

required a great deal of innovation, as very expensive equipment is usually needed for technology of this kind, and this is not usually accessible with the funding available for science in Slovenia. Therefore, we bought an old electronic microscope that had already been decommissioned in Germany and, with the help of LPKF, rebuilt it into a working nanolithography drawer with a resolution of 50 nm. The device is in everyday use and is the foundation for the further development of nanolithography in Slovenia.

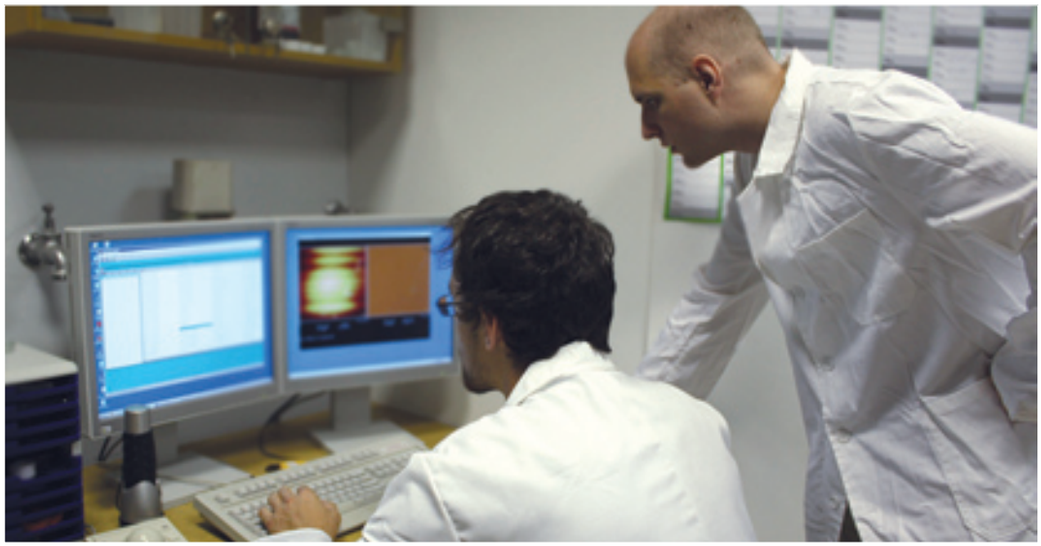
Probably the biggest challenge for NT in Slovenia is in the field of molecular electronics, where we are now trying to make a computer circuit with single

molecules, based on MoSI nanowires. These should interconnect the molecules that also connect them to the outer covalent contacts. This should achieve the required reliability and miniaturisation for the future. Recently, we have shown that these kind of circuits self-assemble and have a structure that resembles the structure of neurons in the brain. This is very inspiring and we hope that we will soon be able to create a type of neuron processor, similar to the network of neurons, but 1,000 times smaller.

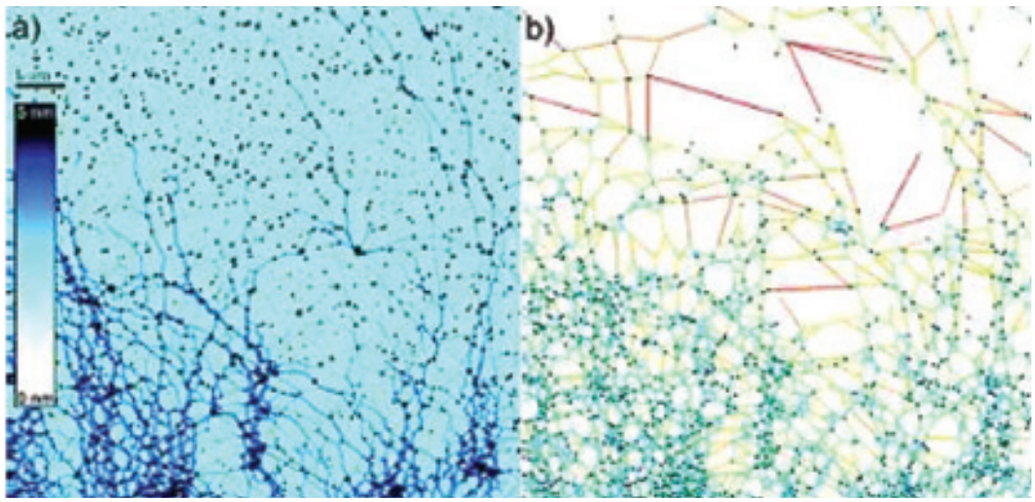
Without doubt, progress in NT is extremely fast not only world-wide but also in Slovenia. It is also very clear that if we wish to benefit from the results of this knowledge in the future, we need to seed it right away. The continuation of the successful work of NiN is an important and crucial step in this direction.



Atomic force microscope (AFM) allows for imaging of the surface topography with atomic resolution. Photo: Martin Rigler



Atomic force microscope (AFM) is controlled via computer which also incorporates software for data analysis and processing.
Photo: Martin Rigler



A network of interconnected MoSI nanowires resembles a neural network (but is 1,000 times smaller!)
(Strle J., Vengust D., Mihailović D., Nanoletters, 2009, 9(3))

The National Assembly

Lecture title:
"STEM CELLS – the Scientific, Medical and Entrepreneurial Challenge"

Nataša Levičar, Helena Motaln and Tamara Lah Turnšek

Lecturer: Prof. Dr Tamara Lah Turnšek

Key words: embryonic stem cells, adult stem cells, cell therapy for incurable diseases, technological breakthrough in regenerative medicine.

Abstract

Stem cells are pluripotent cells with an unlimited potential to differentiate into specialised cells of all tissues/organs. They can self-renew, are able to regenerate damaged tissue and can therefore be used in regenerative medicine. It is believed that cell therapy could perform better than most conventional therapies, as its impact on tissue regeneration processes is stronger and lasts for a prolonged period of time. At present, the development of cell biotechnology is progressing rapidly, driven by large investments. To achieve maximum levels of safety and efficiency, the clinical use of stem cells requires high-tech expertise and equipment, right at the bedside of the patient. A new Stem Cell Centre (CMC) was recently established in Slovenia, organised as a consortium of Slovenian public and private institutions. The aim of the CMC is to develop the commercial potential of novel biotech products that could be used in cell-based therapies primarily in Slovenia.

The beginnings of a new branch of research activities called regenerative medicine can be found in the 1970s, with the idea of developing new therapies for the replacement of damaged organs. The most promising potential strategies in tissue regeneration have been the transplantation of stem cells, the transplantation of laboratory-grown tissue and the isolation of the patient's own stem cells. It is believed that cell therapy could perform better than recombinant proteins and other synthetic substances capable of regenerating and renewing tissues and could be effective for a longer period of time. Understanding the exact stem-cell mechanism of action and technological progress will bring stem-cell therapy closer to clinical use, and it is anticipated that new cell therapeutics will be clinically used within 10–15 years.

What are stem cells and where can we find them?

Stem cells are immature primitive cells with high potential for self-renewal, differentiation and plasticity. Their plasticity allows them to differentiate into more than 200 different types of human cells. Stem cells reside in a variety of tissues, where they are quiescent until damage occurs. After damage occurs, they travel to the site of the damage and replace and regenerate the damaged tissue and cells. This very capability makes them important for cell therapy and regenerative medicine.

Embryonic stem cells are the most notorious and are often mentioned in the media. Besides embryonic stem cells, adult stem cells and foetal stem cells, stem cells isolated from the umbilical cord also exist. Embryonic stem cells are the most potent and plastic and can differentiate into any cell of a human body. We say they are "pluripotent". They were first isolated from a human embryo in 1998 in the laboratory of the pioneer of embryonic stem cells, Dr James Thompson from the University of Wisconsin-Madison, USA. Embryonic stem cells are isolated from the inner cell mass of an early embryo or blastocyst. A human blastocyst reaches this stage at 4–5 days after fertilisation and contains 50–150 cells. Embryonic stem cells remain pluripotent after isolation and differentiate only when they receive a signal to do so. Despite the fact that embryonic stem cells are able to differentiate

Lecturer: Prof. Dr Tamara Lah Turnšek

Development of an embryo and various types of tissues during embryogenesis from fertilisation to an adult human being.

into all three germ layers (ectoderm, mesoderm and endoderm), and that their use in clinical therapy seems indisputable, they have become ethically controversial due to the method of their isolation, in which a blastocyst is destroyed during isolation. It should be highlighted that embryonic stem cells are only produced from surplus embryos originating in a process of in vitro fertilisation, (i.e. in the process of artificial fertilisation), which are generally of a poorer quality and would be discarded anyway.

The other two groups of stem cells suitable for use in therapy are adult stem cells and cord-blood stem cells. Adult stem cells are present in small quantities in a variety of tissues, where they provide for the renewal and regeneration of a tissue. They are present in all people; however, their count and quality decreases with age. The main difference between embryonic and adult stem cells lies in the fact that adult cells are less plastic and can differentiate only into a certain number of cells. We call them "multipotent". It has been shown that their plasticity is higher than previously thought. The development of cell therapy in recent years has concentrated on adult stem cells because they are ethically non-controversial and able to differentiate into many cell types. Additionally, each cell can nowadays be made multipotent by genetic manipulation – such cells are called "induced pluripotent" cells.

Adult stem cells are found in bone marrow but can also be found in numerous other organs such as the skin, brain, peripheral blood, heart and liver. Bone marrow consists of two types of stem cells, haematopoietic and mesenchymal stem cells. They can differentiate into a variety of tissue, such as liver, neuronal, beta cells, and this makes them attractive for cell therapy.

Stem-cell therapy – achievements to date and future developments.

Stem-cell therapy is not a new idea. Bone-marrow transplantation has been used in clinical practice for 40 years, especially in leukaemia. Stem-cell therapy for diseases such as liver cirrhosis, diabetes and stroke seems to be getting closer to reality. Numerous research groups and pharmaceutical companies have oriented their research to the development of stem-cell therapeutics. Several clinical trials have already been performed with encouraging results, with adult stem-cell therapy for myocardial infarction being the most numerous. More than 40 clinical trials have been carried out all over the world, and encouraging results have been achieved in Phases I and II. In most cases, patients experienced better functioning of the heart muscle after stem-cell transplantation, arrhythmias occurred less often and there were fewer subsequent hospitalisations. The majority of new studies already include a Phase III, in which autologous stem cells will be transplanted to patients with acute myocardial infarction.

Currently there are more than 300 different active clinical trials all over the world (www.clinicaltrials.gov). These mostly include adult stem cells isolated from bone marrow for the treatment of diabetes, multiple sclerosis, stroke and for application in orthopaedics. The first promising results on the treatment of diabetes type 1 were recently published. Researchers from the Brazilian University of Sao Paolo reported on the successful therapy of the initial stage of diabetes type 1, in which patients had autologous haematopoietic stem cells transplanted. Promising results have shown that 52% of patients were no longer dependent on synthetic insulin for an average of 31 months. Moreover, after the therapy, 35% of patients required a considerably lower dose of synthetic insulin than before. The exact mechanism of action of stem cells in repairing and regenerating damaged organs is not yet known. Researchers agree that more multicentric studies, which include studies of the mechanistic activities of stem cells need to be carried out and the safety of stem-cell therapy needs to be determined. Researchers anticipate that stem-cell therapy could be widely available within 8–10 years.

Similarly promising results have been published by researchers from the University of Chicago, USA, who carried out a study on patients in the initial stage of multiple sclerosis, resistant to beta-interferon. Patients were treated with their own bone-marrow stem cells and 74% experienced at least partial improvement in their condition, which has remained unchanged even three years after the treatment. These are only a few examples of the approximately 80 successful clinical trials in which adult stem cells have been used.

Despite the huge progress and development achieved in regenerative medicine in the past 10 years, several questions still need to be answered. Safety and the side effects of stem-cell therapy and the immune response to stem-cell therapeutics are just a few of the questions that must be addressed.

Despite the considerable number of adult stem-cell studies, the first clinical trial using embryonic stem cells was only approved in 2009. The American FDA approved a Phase I clinical trial by the biotechnological company Geron

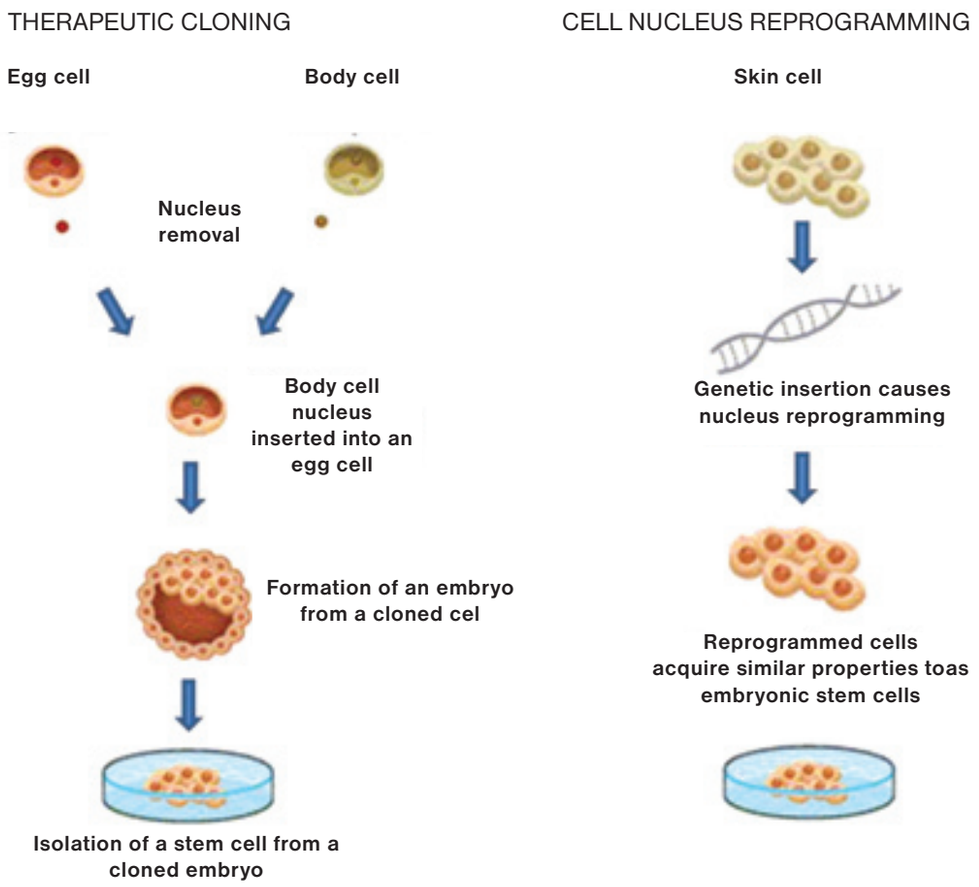


Figure 2: Two ways of obtaining pluripotent stem cells which have unlimited potential for differentiation into various types of cells by using a method of therapeutic cloning. Stem cells are obtained after isolation from the inner cell mass of a cloned early pre-implantation embryo, and by a method of reprogramming body cell nuclei by inserting genetic material to induce reprogramming and de-differentiation of these cells into cells that acquire properties of embryonic stem cells.

for the use of embryonic stem cells in the treatment of paraplegics with spinal-cord injuries. A study, in which neuronal cells obtained from embryonic stem cells will be transplanted into patients, was scheduled for last summer and the results are eagerly awaited. The huge lag in embryonic stem-cell research was mainly due to the conservative politics of the US President George W. Bush, who limited state funding for such projects. Following the election of President Barack Obama, regulations in the field of state financing changed and became more liberal. The result was huge investments of private capital and a new boom in regenerative medicine. The state of California has invested USD 3 billion into stem-cell research and New York State is second in the world, having invested USD 600 million. The United States sees regenerative medicine (and particularly stem cells) as an important branch of technological industry and also as a discipline that will contribute to progress in medicine and therapy. However, new stem-cell companies are emerging everywhere in the developed world.

Stem cells as a business opportunity.

Stem-cell therapy is only in its infancy and yet enjoys tremendous interest among the expert public, patients and the bio-pharmaceutical industry. The majority of research is still financed through government grants, though, increasingly, multinational pharmaceutical companies and private capital investors are showing interest. For example, Pfizer has invested USD 100 million into the development of regenerative medicine (Financial Times, June 2009), followed by GlaxoSmithKline, which has invested USD 25 million into research along with the Harvard Stem Cell Institute. As far as specialised biotechnological companies are concerned, Osiris is the leading company in the field of adult stem cells, and Geron leads embryonic stem-cell research. Osiris has received financial investment totalling USD 225 million and has developed a product from adult stem cells called Prochymal. Prochymal is prepared from mesenchymal stem cells isolated from the bone marrow of healthy donors. The cells are then multiplied in the laboratory, where as many as 10,000 doses can be prepared from 60 ml of bone marrow. Mesenchymal cells of this type are hypoimmunogenic, which means that there is only a very low probability that a treatment would be rejected by the recipient. Osiris claims that Prochymal could therefore be used as a treatment for any patient. The company is in the final phase of a clinical trial in the field of graft rejection after transplantation and is also conducting trials for the treatment of type 1 diabetes and myocardial infarction. Experts from Osiris anticipate that the use of Prochymal will be approved by the FDA as early as this year and they will thus become the first company to have developed a therapeutic product from stem cells. The biotechnological company Genzyme has already paid Osiris USD 130 million for preliminary research on selected new products and also promised a further USD 1.2 billion for the completion of the development of two new stem-cell therapies.

Stem cells are not only interesting for their potential in cell therapy, but also for their possible application in testing the toxicity of drugs. Back in 2007, the large pharmaceutical companies Roche, GlaxoSmithKline and AstraZeneca joined forces with the British Government and founded the non-profit organisation Stem Cells for Safer Medicines (SC4SM). The investment totalled USD 20 million and the task of SC4SM was to develop a method for the toxicological testing of new drugs using stem cells, and subsequently to reduce the cost of developing new drugs.

Regenerative medicine receives by far the most funding both from state and private capital in the USA. However, Western European countries are not far behind. The United Kingdom is leading stem-cell research in Europe with the strategic priority of investment of public funding into stem-cell research. Investments into development are significantly increasing, mostly in the three biotechnological centres of Oxford,

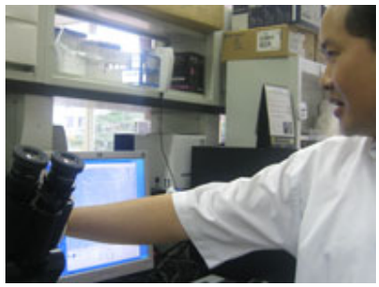




Figure 3: State-of-the-art equipment at the Singapore biotechnological centre, Biopolis, attracts leading scientists from across the world, who apply for projects financed under the umbrella of the Stem Cell Consortium.

Cambridge and London. Between 2007 and 2008, these totalled USD 120 million and funding has increased for this and the coming year to USD 160 million (Department of Health, UK, www.dh.gov.uk).

China and Singapore rank first in research and investments in Asia. China has one of the most liberal laws in embryonic-cell research and the Chinese government is making active investments into stem-cell research. China remains quite secretive about its achievements in stem-cell research. While the majority of Chinese biotechnology remains poorly financed, the government has set stem-cell research as a priority. It has started to invest heavily in academic stem-cell research with the aim of becoming world leaders in this area. As a result, many well-equipped laboratories have been established, employing distinguished scientists, publishing their achievements in renowned international scientific journals. The Chinese Ministry of Science and Technology intends to invest approximately USD 210 million into stem-cell research in the next 5 years.

Small countries such as Singapore have also prioritised the development of stem-cell research and related industry. The Singapore Stem Cell Consortium sponsors projects worth approximately USD 50 million a year. By establishing a modern biotechnological centre, Biopolis, in 2003, Singapore managed to attract top scientists from across the world. Besides academic research, Singapore is very much in favour of investments in small biotechnological companies.
To match more developed countries, Slovenia should consider the strategic finance of stem-cell research. Analysts (Rodman & Renshaw, USA) estimates that this year's USA revenues from the sale of cell therapeutics obtained from adult stem cells would exceed USD 100 million, and this is expected to increase to USD 8.2 billion by 2018. So, what is Slovenia waiting for?

On the initiative of the National Institute of Biology, we founded a consortium called Stem Cell Centre (Center za matične celice – CMC). CMC consists of the following partners: the National Institute of Biology, the University of Ljubljana (Faculty of Biotechnology, Faculty of Medicine), the Institute of Oncology, Ljubljana, the Institute for Transfusion Medicine, and the companies Bia d.o.o., BPK d.o.o., Educell d.o.o., Labormed d.o.o., Pristop d.o.o. and TikhePharma d.o.o. We were led by the following principle: "What we cannot do individually, we can achieve in a consortium with firm connections in development and the economy". Slovenia offers leading researchers and an entrepreneurial culture, with potential for innovations and development in the field of biomedicine. The main goals of the CMC consortium include the acquisition of applicable new knowledge in the field of biology and the clinical application of stem cells, in the field of identification of tumour markers. In the coming years, CMC will develop approaches to diagnostics and treatment of diseases in the field of personalised medicine. This can be achieved by so-called personalised treatment, i.e. by the individual treatment of patients for the purpose of eradicating the causes of diseases and not only their symptoms.

Figure 4: Partners joined in the Stem Cell Centre – CMC.

In the future, the CMC consortium will carry out in-house research focused on the development and introduction of mesenchymal stem cells into the clinical treatment of several diseases, such as bone and cartilage damage, liver cirrhosis, autoimmune diseases and some cancers. The results of the CMC's activities will be faster transfer of basic research into clinical studies. We will aim for the introduction of a personalised approach to therapy, increased added value in the sector of medical technologies, and the development of biopharmacy.

We in the CMC Consortium are convinced that openness to cooperation with different partners in the field of biopharmacy, (nano) materials and environmental technologies represents the foundations for successful development of the CMC. We should also mention that the environmental effects of the technology for the preparation of cell therapies are proven to be significantly lower than emissions and consumption of water sources using conventional pharmaceutical technologies.

Investment remains the biggest obstacle to more rapid development of the research activities and development and translation of applications. This is particularly true in the environment in which we operate, where private venture capital remains very limited and public funding is restricted by the current economic crisis. Nevertheless, we will continue to endeavour to demonstrate to the public and to politicians the opportunities for development niches.

R&D in Slovenia

Quark 2010

(Page 46-192)

- The Slovenian Government
- Institutes and Universities
- Industrial R&D and
- Enterprise Development

Daring Slovenia

Boris Čerin

Various shocks in the times of the global economic recession have brought demands for a more effective linkage of economics to universities and Research & Development work at institutes to the forefront. More attention was paid to the exploitation of development potentials and in this article we will discuss such topics. But we begin with a more current topic, in other words, with the Minister of Higher Education, Science and Technology Gregor Golobič, to whom we first spoke regarding the Research & Development area in Slovenia in times of the global economic crisis, and then about current activities and the Bologna reform of student programmes.

At the beginning of your Ministerial term, the global economic recession had already begun, which probably had an impact on the priority of the tasks, which you had set out. At that time you were arguing for measures which would prevent the weakening of Research & Development activity in Slovenia; you even mentioned strengthening it. How then did your activities take place?

In reality, in 2009, we were faced with such a dramatic decline, in which the public sphere as well as the economy at large found themselves, that we utilised short term measures, with which we wanted to prevent companies who were experiencing such a dramatic drop in orders from taking away their support from already initiated or recently developed research projects, without which even surviving the recession wouldn't represent a long term option for companies to stay competitive. That is why we acted according to the principle of "he who gives quickly, gives two-fold". We acted quickly and we gave two-fold. We increased assets markedly. We completely exhausted the European funds, which were in the past relatively poorly utilised in the time span of one year, due to the proportionately meagre amounts allocated to R & D from the entire amount of resources available. Through tenders of our Ministry and the Ministry of Commerce, we supported hundreds of development projects, which would be, as the economists made abundantly clear to us, put on standby or even sentenced to archivation.

In the second phase, we will be tackling institutional changes. This means doing away with the weaknesses in which Slovenia has found itself. With many issues, it is necessary to re-evaluate our value system, to place knowledge in a completely different role, a support environment, which should demonstrate how serious our intent is to make Slovenia into a knowledge society and adjust it to this priority. That is what we are involved with this year. A lucky circumstance has led us to having to prepare a new National Research Development Innovation Programme (NRRIP) and National programme of higher education (NPVŠ) this year. We're talking about connected components. The working title of both comes from the familiar syntax of Slovenia, Daring Society (DRružba

Photo: Stanko Gruden - STA

The Minister of Higher Education, Science and Technology Gregor Golobič

ZNAnja), therefore Daring (DRZNA) Slovenia.

How did it go with the promised support of the President of the government to Research & Development?

The President, as well as the entire government, have, in this period, sought understanding and awareness of what not increasing support to Research & Development could cause in this area, so that after the crisis period, if I can put it this way, we would stay without the seeds of growth. I would be in the wrong if I said that the government didn't have an ear for these issues. Of course, we also shared the fate of the other ministries, we were not spared through the rebalancing of the budget, though, despite this, we have maintained a positive trend, turned the other indicators positive and increased the funds available for Research & Development by more than 10%. It is clear, that it is necessary to continue this trend; in 2010 we will be successful in reaching an ambitious goal, which is investing 1% of the GDP of public funds into Research & Development until 2012. I am estimating that the support of the President of the government, expressed recently at an innovation conference, will come to fruition to a greater extent under even more difficult public finance conditions.

The global economic recession has set off a number of savings measures, including a decrease in investments and in Research & Development within companies. On the other hand, it is exactly with the intention of keeping in step with global scientific and technological development, that the budget share of funds of the Government of the Republic of Slovenia has been increased for Research & Development in 2009. A portion of the additional funds was additionally anticipated for research infrastructure and the co-financing of new purchases of research equipment, while another part of the additional funds was dedicated to research. Do you believe that this has, or will bear fruit in the future?

I am convinced that this increase will bring results. The more than decade long stagnation of investments in Research & Development, from the middle of the eighties to the crisis year of 2009, when we were faced with only a small oscillation of the same amount of funds, is demonstrated by the fact, that we have a limited number of researchers and there is a disproportionately small number of them working in economics. The low added value of a large portion of the economy is a logical consequence of this. Even if we now had a large amount of funds available to us, we could not reach a lasting

From the left: Vito Turk, Gregor Golobič, Dusan Turk, Wayne Hendrickson, Robert Huber, winner of the Noble Prize for Chemistry. At the front: David Stuart

about-face overnight. This is why it is necessary to gradually increase available funds and invest in human capital, to achieve the absorption ability and reactivity of all spheres, so that we can reach a bridging of the gap between the research and business spheres. I am convinced that the extra monies, which were obtained for R & D in 2009, and will be made available again in 2010, will have tangible results in the mid-term. It is already apparent today, that companies which, in the past, through partial assistance from the state, were able to maintain development ambition, will come out first out of the crisis and already in the first quarter of this year, we have witnessed increased order activity.

The strengthening of research activity in companies includes their wider connection with institutes and universities. For this, it is necessary to ensure: a critical mass of knowledge, sufficient development potential, organisational and manufacturing capabilities and successful cooperation. How can the government help with this?

The government cannot assist here directly, however it will sending a very clear message and, through executing both strategies, the NRRIP and NPVŠ, stimulate such connections and additionally upgrade them, on the individual researcher, as well as on an institutional level. Aside from this, we have with a number of mechanisms and tenders, as e.g. SRRP and Centres of Excellence, demanded from friends, for the consortiums, in which the research sphere and economy cooperate, to take a step forward in the sense of networking or connecting.

The Centres of Excellence are set up to serve as a connecting link between companies, institutes and universities. The reactions to the tender of your Ministry show a large interest in the Centre of Excellence. To what do you ascribe this?

To the largest extent possible, in proportion to the large share of funds, which were available to individual projects in this tender. They enable the purchase of very expensive pieces of research equipment, in the area in which we are underfed in Slovenia. On the basis of a pre-publishing of the tender for the Centre of Excellence, we have identified that we can expect around 70 applications, which is why we have notified potential applicants to connect with each other, because we will not be dispersing the funds from this tender. Particularly because so no one will then have an excuse, that they weren't able to realise their ambitions, due to receiving less than they had requested. Apparently they did not believe the warnings, because up until now, the tender funds have been dispersed. We have received 61 applications for the Centre of Excellence tender; of these, 17 were evaluated as excellent. Because of following the goal of not dispersing funds, we have financed only eight. We will try to compensate for this in the current year in some way with a tender for a Competency Centre, which will be published foreseeably sometime before the summer begins.

The exceptional response to the Centre of Excellence tender and the response of the public, which was not affected in this competition, as well as the reactions of some of those who were not successful in the tender, but know how to separate personal dissatisfaction from a structural move, which this tender represented, have shown that the research sphere misses the identification of key areas, in which the country is prepared to invest more and in the future, also ask more of them.

Until the end of June you will be visiting all eight Centres of Excellence. What are you finding out when you visit people and how would you

This year's winner of the Pregel prize prof. dr Miran Gaberšček receiving congratulations from Gregor Golobič, minister for high education, science and technology.

answer the charge that the Centres for Excellence are concentrated only in Ljubljana?

On my visits I have been noticing, that the Centres of Excellence have already begun with their work. Because I did not take part in their selection, I am familiarising myself with the specific content of their plans on my visits. With a high degree of financing, the responsibility of the fund recipients to reach the planned results from the tender also increases. Time is running. The argument that the Centres of Excellence are concentrated in Ljubljana is, of course, false. We visit all over Slovenia. Companies, faculties, universities, institutes from all over Slovenia are included in the consortiums. In the pre-publishing of the tender it was not emphasized, that we should be following regional distribution with this tender. It is a fact that Slovenia operates as a region inside of Europe, or even globally. This is why we have to join all potentials in some area, so that we can achieve the possibility of a breakthrough. Only this ensures competitiveness, which we so desperately need and is a crucial challenge for the future.

Also, it comes as no surprise that the supporting institutions of the Centres of Excellence are also the best research institutions in the Republic of Slovenia: Jožef Stefan Institute, Chemical Institute, University of Ljubljana. According to all indicators, it is so. Ignoring this fact would mean ignoring the objective indicators of excellence. This does not mean that there is no progress in other areas, or that we don't have good researchers; however the concentration of these in the institutions mentioned is larger due to historical reasons. The inclusion of other potentials from Slovenia, which was the ambition of the tender for the Centre of Excellence, increases the possibility of strengthening the potentials in other areas of Slovenia as well.

You have been putting a large emphasis on innovation at the Ministry as well. What would you say is Slovenia innovativein?

There is not enough ambition to innovate, especially in small and medium size companies. The gap between the knowledge institutions and the economy is too large, and is bridged in very few ways. What we're missing is a systematic strategy, a set-up of a support environment, which would, in a coordinated fashion, encourage such efforts and initiatives. This is part of what we will attempt to address through both national programmes, especially through the National Research-Development programme, which is why it will be renamed the National Research-Development-Innovation programme in the next period.

The government's Council for Science and Technology has begun working in a new composition. Where do you see the crucial role of this Council?

I see its role first and foremost in the shaping of an expert basis for the new NRRIP, and, after that, when the Ministry and the government have done their job, especially in the following years, to see to it that the plan will be appropriately realised. This was first

and foremost a weakness of the strategic documents from the past, the so called implementation deficit. The mission of the SZT will thus be to oversee the execution of the NRRIP, to execute simultaneous evaluation, to update it and to not allow us in a few years to possibly conclude that the goals were good, but the realisation was poor.

If we can now take a moment to discuss higher education. The Bologna process has now been introduced, how would you evaluate the Bologna reform of student programmes?

On the outside level, the Bologna reform of student programmes has been reduced first and foremost to the multiplication of these programmes. We have almost 700 of them. This certainly isn't a sign of quality, but is to a large extent an indicator of coming from the status quo in the reform. From the formula of the current human resource structure in higher education, with the existing assumptions, e.g. how many hours each of the professors should be lecturing, produced a high number of programmes, which are very differentiated in their names, while the same, sadly, cannot be said for their content. This formal nature of the Bologna reform is a weakness, due to the amount of programmes, as well as due to the very mechanical change into 3+2 or rather the 4+1 scheme. We expect that the new National Agency for Quality in Higher Education, as well as the higher education institutions themselves, will make corrections, and effect real curricular, fundamental reform through the evaluation process. We will pay special attention to the didactic viewpoint, therefore the manner of learning, which the Bologna process represents.

However, it is necessary to admit that a lot of things were poorly executed by the government, which should aside from the Bologna reform, ensure appropriate space and equipment, which are the chronically open wounds of Slovenian higher education. Without this, it will be hard to demand quality. All these are problems, which we will be addressing in the new National Programme of Higher Education.

Constant warnings from the economy are ringing out, they claim that they are in dire need of highly educated engineers and scientists? What can we do to gradually change the application trends noted?

Even here there are no shortcuts. However well-intentioned and, on other hand, naive ideas, that it is possible to change the study trends by limiting application to certain student programmes and by increasing slots available in other areas of study have proven faulty. As long as these careers of which there is a shortfall, continue to be poorly evaluated and not valued highly, until there isn't an optimism regarding the future in the areas where these types of profiles are needed, until that point the young will be choosing very rationally. With all of this we have to take into account another, unforgiving and cruel perspective that is the curve of demographic changes. This is not good for Slovenia, our generations are shrinking. I am convinced that the state will have to react to the demographic gap, which is in reality quite disconcerting, by increasing the attractiveness of its higher education and research spheres, as well as taking appropriate measures towards a well thought out immigration policy.

The question of what students can expect from the national government in terms of addressing their problems was the main topic on the agenda of the meeting between students and a government delegation headed by the Prime Minister of the Republic of Slovenia, Borut Pahor.

Photo: Tamino Petelinšek - STA

In your meetings with economists, which you prepared last year and this year across Slovenia, you emphasised a few times, that the recession can also be a challenge. Do you believe that Slovenia will know how to take advantage?

In two rounds of these discussions, January and February of last year and this year, there was a lot of discussion about the recession and the structural problems in Slovenia. During the debates I also simultaneously noticed a large difference between last year and this year. If at the beginning of 2009 this communication was more one sided, and the bulk of thought addressed the state as some almighty and all providing construct, the year 2010 saw a realisation that we will have to utilise partnerships to reach such a state, in which every side will complete its part of the mission; that it is about a very continued striving of all of those involved in the creation of the environment, in which different values will encourage different processes. The state is prepared to do its part of the job here. If the society as a whole can manage some sort of discussion about Daring Slovenia, about a new developmental agreement, then we will be able to say that the recession sobered us up, and that we knew how to take advantage of the challenge, which it represents and with which we were faced. It is too early to say, whether or not we will be successful. I have been striving for this. Not because I am an optimist, but because I know that it is necessary to request in so many words the impossible, if you want to be a realist.

The National Research and Development Programme

◊ Analysis of results, progress assessment and outline for the future

Boris Čerin

"This year marks the conclusion of the National Research and Development Programme 2006–2010. As part of the development of a new national research & development programme (NRDP), the Ministry of Higher Education, Science and Technology prepared an overview of the goals and tasks set out in the current strategy and requested an assessment from the Slovenian Research Agency as to how individual elements of the NRDP have been put into practice. The ministry wanted to use a critical analysis of implementation as the basis for preparing a new NRDP," said Dr Franci Demšar, the director of the agency, introducing the main topic of our discussion. "They compiled a memo for the assessment of progress on the NRDP 2006–2010 and asked the agency to assess the vision, principles, objectives and tasks for relevance, as well as to offer an assessment of how particular goals and tasks have been carried out. The ministry also expected us to offer a substantive assessment of the activities (principles, objectives and tasks) important to the agency. This assessment focused on results achieved, changes initiated, reasons for inactivity and proposals for improvement."

How did the agency approach the progress assessment of the NRDP and completion of the memo?

We submitted what was compiled in the progress assessment memo to the Ministry in February 2010. The document was based on the assessments of the permanent expert bodies of the agency i.e. members of the relevant scientific-research councils and the Scientific Council of the Agency. It is an extensive document, a questionnaire with more than 350 objectives, sub-objectives, tasks, measures and principles.

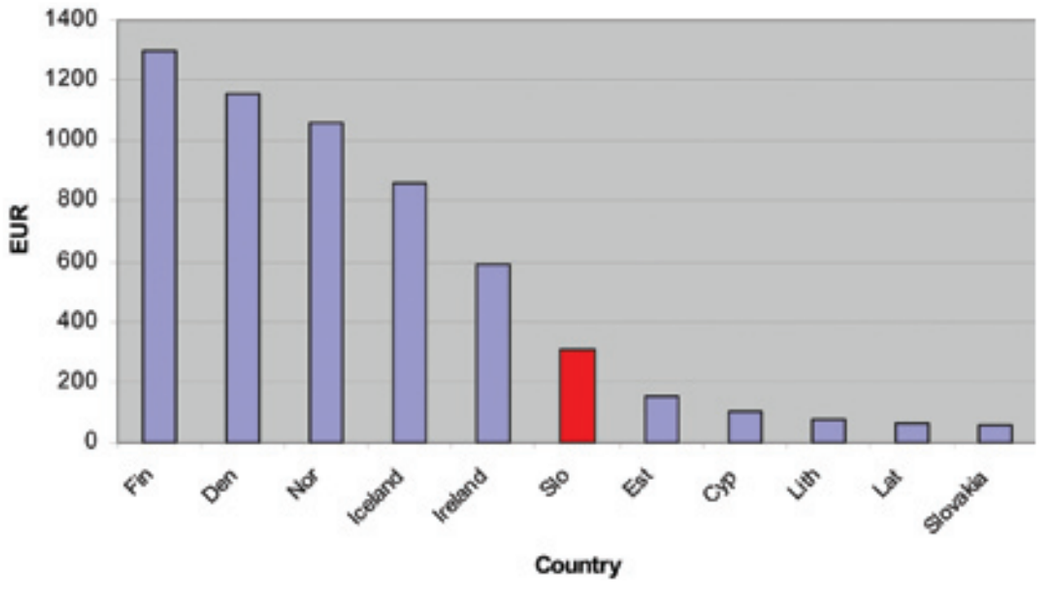
The agency also prepared a substantive analysis of activities important to the agency, as requested. The analysis of results and discussion at the Scientific Council of the Agency resulted in a document, which not only presents in detail the results of the NRDP as implemented, but also provides recommendations for the preparation of a new NRDP. The agency's proposals were presented at the consultation session on strategic changes in policy of the Ministry on 30 March 2010.

What are the recommendations put forward by the agency for the preparation of the new NRDP? What should the NRDP for the future look like?

The current document, with its more than 350 objectives, sub-objectives, tasks, measures and principles was too extensive for monitoring the implementation of tasks and objectives. The new document should be more compact, with no more than 15 pages and a clear vision on scientific excellence, as well as technological and social development. The objectives should be clear and measurable. The agency also proposed that the annual progress assessment of the NRDP could include revisions of the document for the next five-year period. The agency believes that the ten points listed below present the main highlights crucial for the structure of the new NRDP, namely:

1. scientific excellence;
2. an increase in R&D investments;

R&D expenditure per person in 2008 (in EUR)



3. competitive and stable financing of research (in comparison with the rest of the EU);
4. better cooperation with the business sector;
5. improved R&D infrastructure;
6. language (the option of holding lectures in English at the second and third Bologna levels);
7. cooperation between universities and institutes;
8. the option of changing relations between fields of science;
9. priority fields of R&D funding;
10. EU funds – inclusion in the European R&D and higher education area.

The conclusion of the NRDP 2006–2010 is also a time for analysis and comparison of the results achieved by Slovenian science and R&D in the period. The so-called Barcelona target aims at investing 3% of GDP in R&D. What do the latest data on R&D investments indicate and how does Slovenia fare in comparison with the other EU Member States?

Statistical data on gross domestic expenditure on R&D in the period covered by the current NRDP do not point to a constant growth trend. Gross domestic expenditure on R&D as a proportion of GDP was 1.44% of GDP in Slovenia in 2005 (1.82% in EU27) rising to 1.56% in 2006 only to fall again to 1.45% in 2007. The data for 2008 shows the share rising to 1.66% of GDP (1.9% in EU27), and an assessment for 2009 does not point to another fall in R&D investments as a proportion of GDP. The public funding and its share in total R&D funds went through similar rises and decreases within the period in question. The highest share of public funding in total R&D funds was in 2005 (37.2%) and the lowest in 2008 (31.3%). Slovenia ranked eleventh among EU Member States on share of R&D expenditure in GDP in 2005 and ninth in 2008.

R&D expenditure per person is an even more significant indicator of the situation in R&D investments. What does the analysis show?

On this indicator, Slovenia significantly improved in 2008 (EUR 307) from 2005 (EUR 207), but remained 14th among EU Member States, as it was in 2005. This is still a relatively small amount compared to the top performing countries (Sweden EUR 1,341 and Finland EUR 1,296) but is slightly closer to the EU average (EUR 476) than in 2005. It should be noted that the cost of research equipment urgently needed to perform quality R&D work is more or less the same everywhere. Wealthier countries can, of course, offer a better infrastructure for R&D.

Your ten points include competitive and stable financing of R&D. Which issue you aim to address and why?

The current NRDP specifies the proportion between programme and project financing at a maximum of 40% and a minimum of 60% of the total budget for financing R&D programmes and projects (including CRP), respectively. Changes between project and programme financing in the four years are presented in table 1.

The agency believes that the proposed ratio between programme and project financing, stable (programme financing in our case although it is not classic core funding) and competitive financing (public tenders for research projects), does not provide for optimal conditions for R&D in Slovenia. During preparations for the new NRDP in 2009, the agency made an international comparative study of the proportion of stable and competitive financing of R&D activities in EU Member States. The international study shows that the long-term goal set out may not be reasonable. The agency advises further reflection for preparing the new NRDP. Slovenia is already among the top three countries by share of competitive financing in public R&D expenditure. The most developed countries have a share of competitive financing in public expenditure between 20% and 35% (with the exception of Germany, which has around 45%). The share of competitive financing has been rapidly increasing in general in the EU in recent years, but the real question is whether balance has already been achieved. To what level the share of competitive financing can be increased without harmful consequences is a matter of deliberation.

Table 1: Division of budget between R&D programmes and projects (with CRP) 2006–2009

(Share)

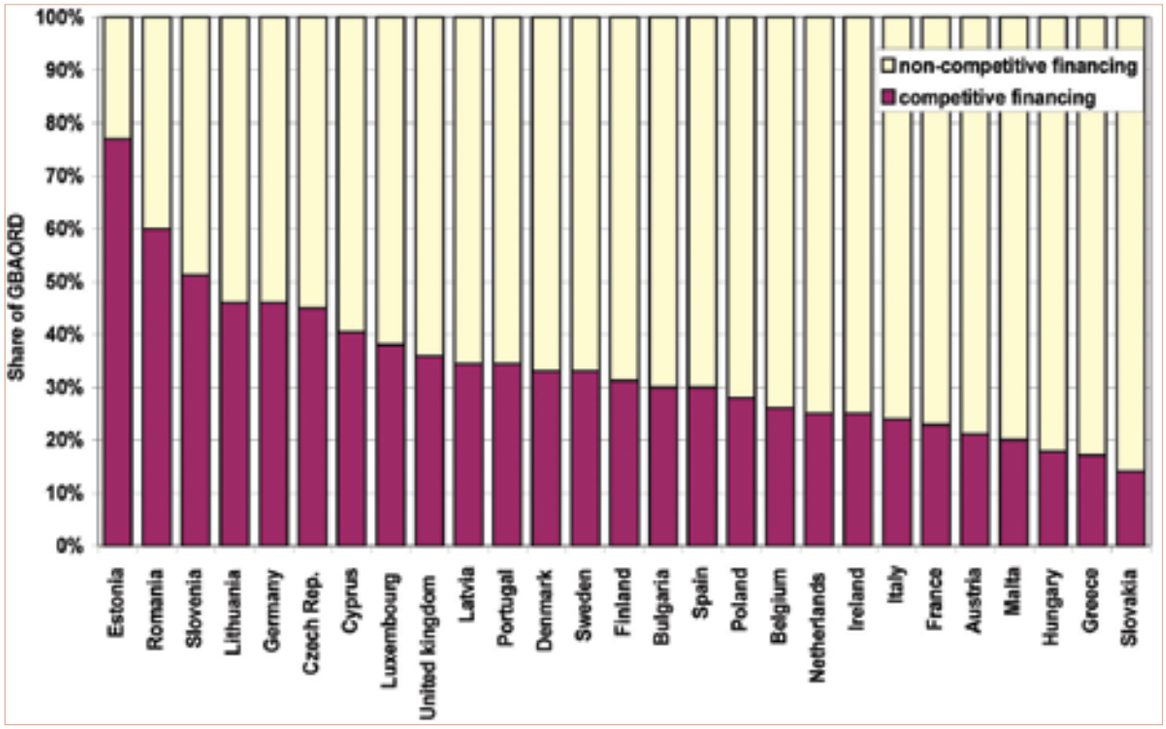
	2006	2007	2008	2009
R&D programmes	61.6	62.3	61.0	58.7
Research projects and CRP	32.8	37.7	39.0	41.3

Dr Franci Demšar, the director of the Slovenian Research Agency

Scientific production and its significance are certainly two indicators of the level of R&D activity in Slovenia. How does the agency monitor scientific production, what tools are used to assess its quality and where do we currently stand in Europe?

Quantitative indicators for measuring scientific production and its relevance, and thus to a certain extent research

Share of competitive financing in total public R&D expenditure in EU27

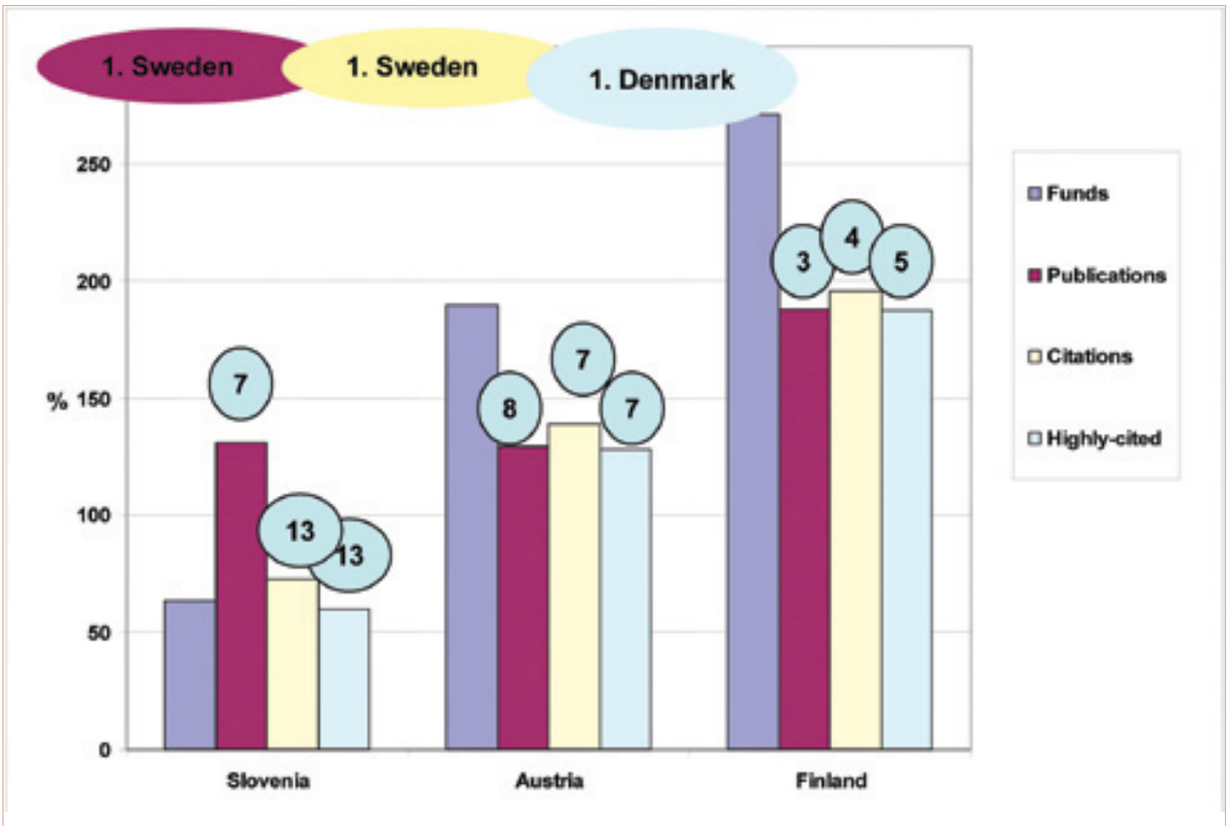


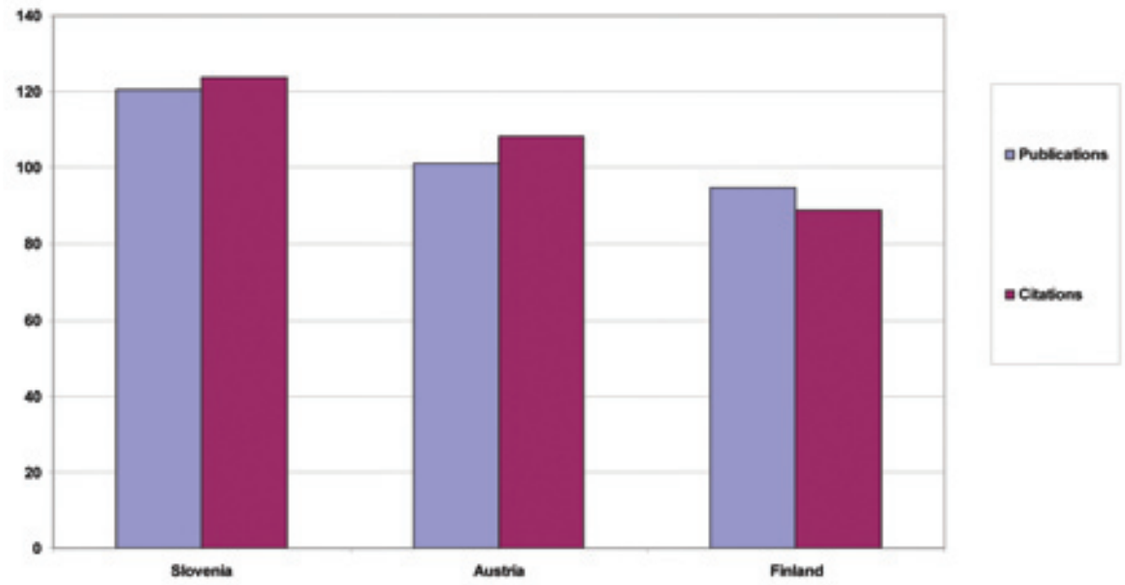
quality, comprise the following bibliometric indicators: number of scientific publications, number of citations and number of highly cited scientific publications in any given period in journals indexed in the SCI, SSCI and AHCI bibliographic databases. We have compared the results of EU Member States in the past 5 and 11-year periods, accounting for the country's population size and in comparison with the EU average. Slovenia exceeded the EU average for number of publications by 30 percentage points in 2004–2008, whereas the number of citations and highly cited publications in 1998–2008 equalled 73% and 60% of the EU average, respectively. Slovenia ranks 7th among EU Member States on number of articles per million people and 13th on the other two indicators. There is a further comparison available with the two "old" EU Member States with which we often try to compare ourselves. Sweden holds the top place among EU Member States by number of publications and citations, while Denmark is strongest on number of highly cited publications within the structure of all publications. Furthermore, if we compare the total annual R&D expenditure, we can observe that Slovenia still significantly lags behind the EU average on that indicator (63% of the EU average).

The comparison of the number of publications and their citations from two periods (1999–2003 and 2004–2008) points to a rising trend in the number of publications and their citations with regard to the EU average. The growth in the number of publications exceeded the average growth in the EU by 20%, while the number of citations exceeded it by even more.

When we speak of scientific production, we often encounter the term

Articles and citations (2004–2008) and Highly-cited articles (1998–2008) per million people compared to the EU (EU=100)





Growth trend in the number of articles and citations (2004–2008 compared to 1999–2003) per million people compared with the EU (EU=100)

"relative impact factor". What significance does that indicator have and what are its results for Slovenia?

The relative impact factor is a standardised international bibliographic indicator measuring the relation between the number of citations and the number of publications with regard to the global average impact factor in an individual research field. The basis for the calculation of relative impact factor are publications and citations in the Web of Science international bibliographic database. It is statistically relevant and standard bibliometric practice to take into account analyses of bibliometric trends over overlapping five-year periods. In our assessment, the trend in relative impact factor is positive for Slovenia, although the factor has remained unchanged for the last three five-year periods (0.67). Individual research fields, of course, fared differently compared with the global and EU average, depending on the human and financial resources and, naturally, research results.

Access to international sources of scientific literature and databases also affects scientific production. How does the agency address the issue of the increasing need of researchers to access the latest foreign publications from their home office?

The Slovenian Government and the agency increased funding towards the purchase of foreign scientific literature and databases by 40% in 2009 from 2008, which was a notable achievement. The share for consortiums rose by a hefty 75%. The agency complied with two strategic decisions in two significant ways – by supporting consortiums of libraries and by primarily funding databases with accessible primary sources and full texts (mostly scientific journals).

Dr Franci Demšar

Increased investment of the agency in international scientific literature means primarily two things: this has freed up the budget of libraries that had been earmarked for such expenses, and increased funding by the agency enabled access to many more researchers than before. This was achieved by the introduction of the so-called 4 + 4 model. The basic funding condition for the selection of the consortium was that it included all four Slovenian universities and at least four other R&D organisations. Despite the initial concerns, we found that the simple 4 + 4 model was exceptionally important for improving access of users in Slovenia to such literature. According to the SICRIS, we estimate that more than 90% of all Slovenian researchers are directly taking part in the current 4 + 4 model. We believe that the remaining 10% have indirect access via consortium members.

You state that language is a major element to be addressed by the new NRDP. Why does the agency deem classes in English to be so important and what measures do you propose for the preservation of Slovene?

Language is an important element worthy of special consideration within the new NRDP. We believe that higher education in Slovenia is not accessible, which is, of course, reflected in science

Table 2: Structure of financing international scientific literature and databases through agency public tenders

Year	Co-funding foreign scientific literature (EUR)	Co-funding consortium activities (EUR)	Share of co-funding of consortium activities (%)
2006	2,086,463	223,251	11
2007	2,100,000	231,675	11
2008	2,200,000	338,921	15
2009	3,520,000	1,421,458	40

and research, notably in the relevance of Slovenian scientific production. We are not alone in believing that higher education in the country is closed off. Several speakers highlighted the issue at the consultation session mentioned earlier. There are no foreign professors teaching courses and the area is not interesting to foreign students. The Higher Education Act should be amended to enable classes in English, notably in study courses at the third and partly at the second Bologna levels. Of course, to improve the status of Slovene in science, funding would be required for textbooks in Slovene and glossaries in all fields.

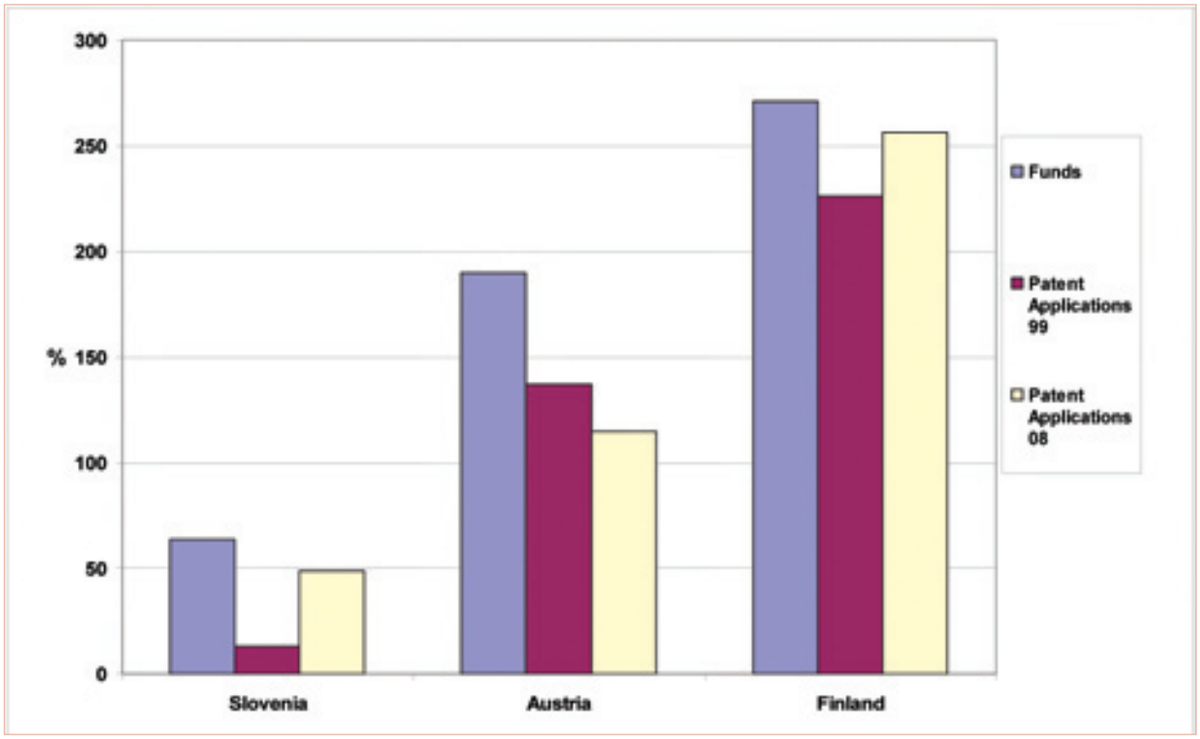
What has been the trend in patent applications within Slovenia in the past decade?

Slovenia's initial levels in 1999 were quite low. The data points to a strong growth trend in the number of European patent applications. Slovenia achieved a good third of the average number of European patent applications per million people in EU27 in 2003 and the number rose in subsequent years to a half the EU27 average. Given the rising number of European patent applications in 2007 and 2008, we expect a further closing of the gap with the EU27 average, although strong growth trends can also be observed in certain other new Member States.

The R&D policy of the EU perceives co-operation with the private sector and the transfer of solutions to society as a major contributor of scientific research towards the implementation of the Lisbon objectives and the Europe 2020 objectives. How does the agency encourage such co-operation?

The agency promotes the transfer and use of domestic know-how in social and economic practice by including the criterion of promoting and rewarding the transfer of domestic know-how as an important evaluation indicator of research excellence in the process for obtaining budget funding, through all regulations and evaluation practices. Additional annual co-funding is provided by the agency to research programmes on the basis of participation in the education process (184 researchers in 2008 and 339 in 2009), with the aim of linking research and education.

An analysis of 100 completed research application projects in 2008 and 77 such projects in 2008 that were co-funded by the agency and carried out within companies or co-financed by companies has shown major economic, technological, social and infrastructural effects on Slovenia's development. Despite the small scope, dispersion and variety of objectives and activities of organisations co-funding the completed projects, they have shown immense research potential, in



Trend in the number of European patent applications (2008/1999) per million people compared with EU levels (EU=100)

particular, within the research fields of technical sciences.

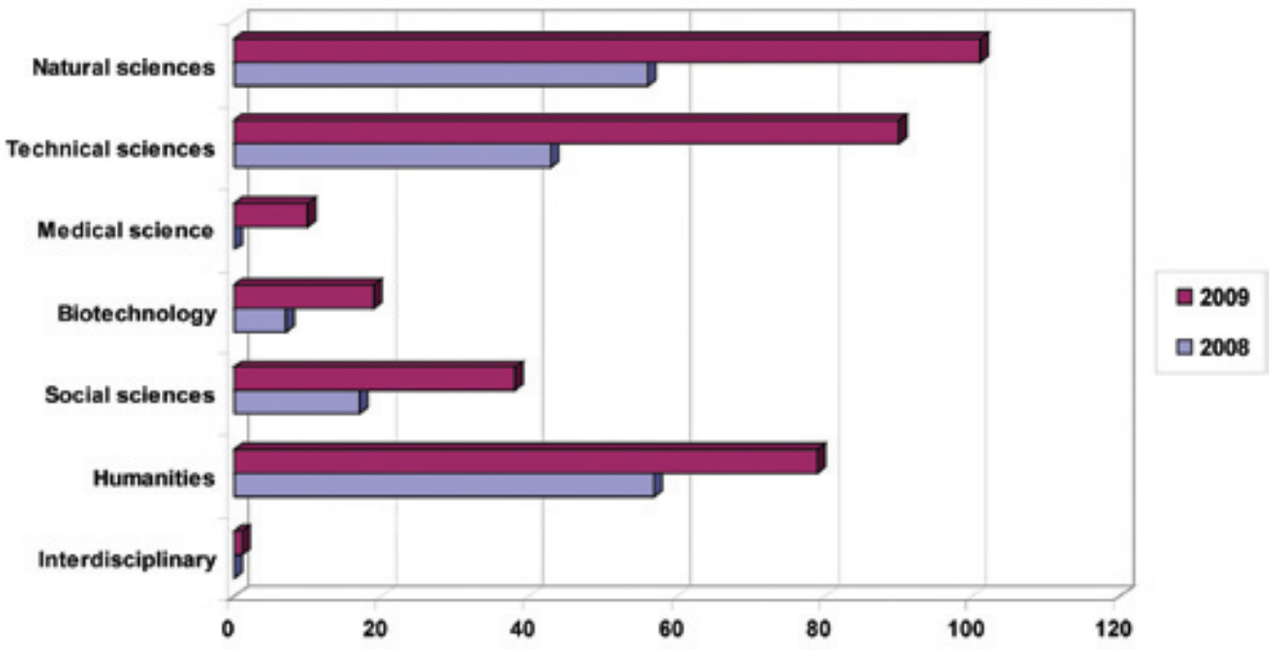
How does the agency monitor and evaluate the links between the public and the private sectors?

The systemic revision of the Rules on Quality Assessment and Funding of the R&D Programmes paved the way for cooperation in R&D between public research institutions, notably universities and public research institutes, and research organisations, as well as companies and the private sector. A system for monitoring data on contractual relationships and acquired funding between researchers in programme teams and users of their know-how was developed. The data has shown that co-financing by companies totalled EUR 14.1 million in 2005, EUR 14.8 million in 2006, EUR 21.8 million in 2007 and EUR 25.1 million in 2008. Of the total of 288 R&D programmes co-funded by the agency in 2004–2009, 110 involved links between companies, universities and public research institutes.

Your ten points include EU funds and inclusion in European R&D and higher education. What instruments does the agency use to encourage applicants from Slovenia to take part in the European calls for proposals, for example those of the European Research Council (ERC) and the European Science Foundation (ESF)?

The Ministry decided in 2009 to link the national schemes for funding basic science with invitations to the ERC and their evaluation, to encourage Slovenian researchers to take part in the ERC's calls for proposals and to make the system for science funding friendlier to researchers. The ministry and the agency contributed their joint efforts in an attempt to find the most suitable form of encouragement of this kind. The agency developed a new instrument and in 2009, implemented it in practice for the first time. It entails co-funding Slovenian participation in projects that received a positive mark under international review, but were not selected for co-funding. The instrument has the greatest effect on meeting the objectives of the NRDP, (i.e. on international recognition of programme teams, strengthening international R&D co-operation, enhancing the role of Slovenia in strengthening the ERA and the EHEA and promoting the mobility of researchers).
The agency aims to use the new instrument to support applicants to international calls who received high scores from international reviewers under strict assessment criteria in the highly competitive international environment, but who were not accepted for co-funding. In this way, the agency intends to encourage high-quality Slovenian scientists to take part in international calls for proposals, where the chances of success are relatively small due to the extremely intense competition and the sheer number of applications. That is why researchers often face a dilemma as to whether to invest their already limited resources towards the preparation of proposals of this kind at all. This will therefore encourage all of those who have achieved undisputed scientific excellence at the international level. We believe that this can be an important contribution towards increasing the number of high-quality submissions and will therefore increase the chances for success with international invitations. The international calls for proposals for funding research projects included in the instrument are the ERC Starting Grant, ERC Advanced Grant and the ESF-EUROCORES programmes.

The number of researchers engaged in regular teaching at another institution in addition to research in 2008 and 2009



Challenges in spin-off creation in Slovenia

Alenka Mubi Zalaznik
Dr Franc Gider

The whole of the EU, not just Slovenia, is confronting the so-called European research paradox. This issue is being addressed differently in every EU Member State, but the need to improve the transformation of European research investment into successful innovation is shared by everyone.

Dr Franc Gider, the Director of the TIA

Public research funding today primarily focuses on academic research. Funding for the early stages of the commercialisation process has been reduced, resulting in insufficient incentives for the process of putting knowledge into the market. Many researchers are driven by citations and publications, while more commercially interested scientists are forced to sell their research results before their value has increased. To start a company before the commercial opportunities of this new business have been valorised is also not a good idea.

Within this article, we shall examine the challenges of spin-off creation in Slovenia. Establishing a new venture is the most radical way of bringing a new technology or service to the market. In many cases, technology transfer takes other paths such as licensing, joint R&D industry ventures or projects.

The methodology and substance for a national programme has been partly delivered by an EU project called VALOR (Development of an effective joint trans-national knowledge valorisation process and co-ordinated innovation policy) – an international initiative to reshape valorisation in Europe. The VALOR initiative is supported by the European Commission as an InnoNet project; 15 European technology-implementation agencies are collaborating in the European VALOR consortium to increase the rate of change in technology valorisation in Europe.

The Public Agency for Technology in the Republic of Slovenia (TIA) is a partner in the project. In a VALOR forum in Amsterdam this year, entitled "How to Convert Science & Technology into Business", TIA presented a national programme for commercialisation of knowledge as good practice. One of the companies supported by the programme (Lenis Wound Care Ltd.) was chosen as the best project.

The timing is right

There are a number of cases of successful spin-offs, especially those originating from research and technology organisations (RTOs). Universities are only now in a position to open up and examine the benefits of more active management of their intellectual property in terms of licensing and spin-off creation.

The willingness and internal acts that allow and manage the transfer of technology or/and knowledge for the market from universities or RTOs are necessary steps, and are most welcome ones. But they are far from enough. An active approach must be taken: technology-transfer offices should take the lead as intermediaries to research the market. All this is important, yet the decision, the energy and the courage for spin-off creation is primarily down to the team of researchers and business developers to draw up and implement.

And the state? Ideally this would be the time to seriously consider enhancement of at least two areas of activity supporting commercialisation of knowledge (i.e. support for new spin-off companies). One is to create a pool of specialists (business developers and so on) and the other is to design a programme to support the activities required before the establishment of a spin-off, whether these stem from a university, RTO or a collaborative project that has produced outputs with commercial potential. The existing network of public and private venture funds, banks and business angels will monitor the activities of the actors included to be able to invest in companies when ready.

There are already many public programmes enabling financial support for R&D projects: these are available to different types of consortiums and target the public. Knowledge transfer from research to industry can take several forms. There is no single source of knowledge for an innovation; the knowledge source could be any or a combination of academia (researchers, university/institute employees) and the commercial market (users, customers, firms/companies acting in that market).

But where can a researcher (and partners) turn when he or she realises that a research result can be commercialised and put on the market in a totally new company? Shouldn't we, in the name of future development, support the establishment of new high-tech start-ups that might create significant added value?

The difficult path to the market

The gap between a promising research result and the creation of a company has been identified. We can speak of the two sides of the same coin. While the research result is the final step for the researcher, creating a business is the first step for commercialisation, and establishment of a company is often not the next logical step.

The following model was developed within the VALOR project..

Validation of the potential product, exhaustive market analysis, a solid business plan and IPR protection must all be considered in bringing technology or a service closer to the market. Especially in the field of life sciences, products will, in all likelihood, not be suitable for an end-user soon, but will only be of value to certain larger companies that can develop the idea into a product and bring it through the difficult and costly registration procedures until it is ready for the end-user. As well as time, this demands money and this is something that a start-up company usually does not have.

Let's identify the steps a technology start-up must take before it can commercialise its products or services.

The commercialisation process must start with a business idea or business concept. The detailed activities leading to a verified business idea are almost impossible to describe. Instead, we can identify the main assets and competences required. Clearly, there must be a relevant market (users, potential clients) that seems attractive from a growth perspective. A research result (new knowledge/technology) is needed, with unique properties or functions that have the potential to provide long-term competitiveness in applications addressing the market opportunity. Then there is design, both having someone who is able to design an attractive proposition that applies the competitive advantage of the research result and also using existing technologies to create a product or service architecture that addresses users' needs in a cost-effective manner.

Once this has been addressed, the process has become a verified business concept embodying a business idea. We need a product or service prototype, a verified technology. To reach a target customer, a value proposition must be made clear. To learn enough about the environment of a new business, market analysis must be carried out.

Secondly, an implementation strategy is required. This covers issues such as where to get the money and the right partners. How can knowledge be protected (intellectual property rights, or IPR), and how do can IPR be managed? Who are the employees? Are they already known to the team? It is crucial for any young business to have a good team. This team will change during the business's growth phase, but it is close to impossible to get off the ground without a dedicated team of people.

With a verified business idea in place, the commercialisation process is ready, so that one could say that a business has been created. We have a company.

There are different issues now: creating an adequate management team, plus the reference customers and partners needed to operate the business model, creating clear financial projections and analysis of capital needs to expand the business, and an operational plan describing the business's expansion.

Two contributions are particularly important in this phase: management and commercial. The former is able to exploit the business idea and turn it into real business. The latter verifies the value proposition and the business system with both reference customers and partners/suppliers, relationships that are needed to implement the business model under which the company is planning to operate.

Finally, once a verified business plan is in place, the next step is to move into full operation. This stage is characterised by an operational business model,

Alenka Mubi Zalaznik

achieving the first customer base in place and revenue growth. A management team is now proven and the company is on its way to expansion.

All of the above points need to be clarified. For example, winning the first customers will need development of the cost structures and business margins that support a growth scenario. Additionally, the position of a company in (global) value chains will need to be established, as a relevant network of partners will lead to business growth. This contribution also represents the development of assets (most often in terms of IPR, employees and networks) needed to support the company's position in the value chain; moreover, it entails the development of a competitive strategy that defends and extends the company's market position.

Each of the above processes is also subject to globalisation (i.e. they are carried out in international knowledge, technology and capital markets). The commercialisation process is therefore subject to global threats and global opportunities that depend on the competitive landscape and the innovation capabilities of the team carrying out the valorisation process.

The relevance of a global network is examined in the Open Innovation paradigm, which assumes that companies can and should use external ideas, and internal and external paths to the market as they advance their technology.

Any of these stages of setting up a new business is critical and requires specialised support. In terms of government support, a special mechanism is in place where spin-offs can obtain seed money to upgrade their operations with partners and capital. This can result in a more holistic approach to support of spin-offs. Today, this process is regarded merely on a project level and a very rigid set of award criteria applies. These need to be expanded to support the strategic development of companies.

Several steps (projects) may need investment to develop a technology up to the market phase. A verdict that the business is unsuccessful should not be given too early and access to further public support not be denied too soon.

These are only some reasons why existing public programmes are not suitable

for start-ups. In evaluating a project against the current rules for public support, problems include a spin-off failing to generate an immediate return on investment (the product may not be developed to the stage where it can be marketed), or not being able to generate new jobs as the market to provide sustainable revenues is not yet there.

We therefore argue that other indicators, both qualitative and quantitative, must be taken into consideration, ideally stemming from the application of the company/spin-off involved.

VALOR programme in Slovenia

So, how is spin-off creation supported in Slovenia? The Public Agency for Technology and the Ministry of the Economy made a public call for applications in 2008 to support commercialisation of knowledge from universities and RTOs. A total of 18 projects (companies or companies-to-be) have applied for grants of up to 150,000. Of these, five were selected and are now in the implementation phase. In October 2009, the results of the grants given were evaluated.

Dr Franc Gider, the Director of the TIA

The applicants mostly came from the IT and life-sciences sectors; any follow-up public call is expected to generate applicants from the same sectoral backgrounds. Grants were given to two biotechnology companies, one medical company and two IT companies. We discuss three of these five companies below.

Acies Bio was supported in its early stage, the so-called invention stage. The project's aim was to research further in order to create a new tetracycline-based antibiotic based on an invention.

Acies Bio's aim is to complete the first stage of R&D, filing a PCT patent application, developing the methodology and "proof-of-principle" of the proposed technology for biosynthesis and semi-synthesis of novel tetracycline antibiotics.

A novel gene cluster for an atypical tetracycline was discovered at the University of Ljubljana. The discovery allowed the development of entirely new tetracycline molecules through biosynthetic and semi-synthetic engineering. Acies Bio obtained an exclusive and unlimited licence to use and commercialise the innovation, and an EPO patent application was filed. According to structure-activity-relation (SAR) analysis, the potential activities of novel tetracycline analogues are not limited to antibacterial use, but can also be used in treating fungal and protozoan infections, inflammatory diseases, multiple sclerosis, and neurodegenerative disorders.

With Acies Bio's experience and know-how in the field of biosynthetic engineering, strain and bioprocess development, the proposed technology for biosynthesis and semi-synthesis of novel tetracycline antibiotics will be developed further using SAR analysis as a guideline in designing novel drugs with predicted clinical applications. The developed technology and patent protection will enable the company to look for strategic investors or industrial partners for further development, R&D collaborations and licensing agreements.

The current global market for tetracyclines is worth over a billion dollars, with over 60% of the market dominated by the last two tetracyclines developed: doxycycline and minocycline. With new patents filed in this field and the recent FDA approval of tigecycline, which is estimated to generate over US$800 million in sales by 2011, a new drug with good pre-clinical activity has immense commercial as well as medical potential, especially since these molecules may also be considered for the treatment of non-antimicrobial diseases, such as cancer, neurodegenerative, autoimmune diseases and others.

Novel gene-cluster codes for biosynthesis of an atypical tetracycline molecule present a completely new template for biosynthetic and semi-synthetic alterations, and thus the potential to design entirely novel tetracycline-based compounds. Technologies for manipulation of the gene cluster, microbiological methods for growth and transformation of the strain, and bioprocesses for the production of novel tetracycline analogues will have to be developed. Semi-synthetic approaches to modifying the new template molecule will also have to be formulated.

Lenis Wound Care Ltd. Lenis Wound Care Ltd. is a company in a very early stage of development, established in 2008. Core activity is the development and marketing of modern medical products based on the healing properties of medical maggot excretions.

Medical maggots have been widely accepted as capable of chronic wound debridement and, possibly, of assisting in wound healing. Lenis Wound Care Ltd. will eliminate the negative side of maggot therapy by using just maggots' healing excretions/secretions (ES) instead of live maggots.

The healing power of medical maggots has been known for centuries, and has been gaining acceptance lately in the medical community for treatment of chronic wounds, mainly in the USA and in Europe. The maggots' ES contain a mixture of synergistically working compounds that debride a wound, reduce microbial load and stimulate cell proliferation. The method would doubtless gain a much wider acceptance if the application of live maggots to the wounds could be eliminated.

The research group at the University of Ljubljana led by Prof. Dr Nina Gunde-Cimerman has worked with medical maggots for several years and has developed a high-yielding process to obtain maggots' ES. The applicant company, Lenis Wound Care Ltd., was

founded recently with the goal of commercialising the development results of the research group. The aim is to produce and use standardised larval ES in modern and innovative medical devices, e.g. gels and wound dressings for chronic-wound debridement and for wound healing.
The incidence of chronic wounds in developed countries is around 0.78% and the prevalence ranges from 0.18% to 0.32% of general population. With population ageing, these numbers increase, and therefore Europe has the highest figures, relatively. The company's conservative estimates indicate that the market for prescription wound-care products based on medical maggot ES will be worth about EUR 30–40 million in Europe and EUR 20–30 million in the USA three years after the first effective product is introduced.
The technology for developing these target products is already available, so the company is not relying on any technical/technological breakthroughs to complete product development. Production of standardised maggot excretions/secretions requires the same quality-management procedures as used in production of active pharmaceutical ingredients. Manufacturing technologies for different semi-solid pharmaceutical forms and wound dressings have also been available for a number of years.
The company estimates that it will require 14 months for initial product development and another 36 months to first product launch.

Optilab Ltd. is an IT company developing software for insurance-fraud management (commercialisation of an intelligent fraud-detection system based on analysis of accident records).

The product solves a major problem that insurance companies face; it reduces losses due to fraud. The general estimate is that between 10% and 18% of all motor-insurance claims are fraudulent. By using the Optilabs product, insurance companies will be able to significantly reduce their losses and reduce costs, and this will enable them to reduce insurance premiums and thereby gain an advantage compared with their competitors, resulting in an increase in business and an increased market share. Motor-insurance companies would be able to save between 22.8–41.3 billion on their targeted markets by using this product.

The product is a global innovation. It is an intelligent system that innovatively combines the most modern computer methods in an effective fight against insurance fraud. Methods include artificial intelligence, machine learning, expert systems, statistical-probability, advanced visualisation, and so on. The product efficiently combines these approaches and methods, and enables insurance companies to automatically analyse accident records and effectively visualise results, offering support for the process of effective resolution of suspicious cases and a significant reduction of losses due to fraud.

In order to fully develop the project for commercialisation, Optilab will have to successfully combine several techniques. The most demanding tasks are those related to: (1) choosing and implementing the right intelligent methods, to suit customers' data; and (2) implementing speedy and scalable architecture that will make the product fast enough.

Experiences of spin-offs in general

While the projects/companies supported within the VALOR programme have not been yet finalised, some conclusions can already be drawn. The need to offer special public support for research results from universities and RTOs is evident. A research result must be evaluated through different, entrepreneurial lenses – capabilities which researchers usually do not have. They can see the validation potential, but building a team, providing financial resources and bringing the product to the market is far beyond their abilities.

Adding value to the supported projects is yet to be proven on the market, but the identified group of end-users offers high hopes on returns on investment. According to the business plans submitted by the five supported companies, about 70 new jobs for highly educated people will be established within five years.

The establishment of spin-offs in life sciences is particularly encouraging, as the health sector in general is identified as one of the most promising for the future, but is also very difficult for start ups.

The benefits of a public programme for the commercialisation of knowledge include awareness-raising for researchers and their employers (and also for industry and the public), and a system of public support in development that can work in the very early phases of business creation. Of course, the funding available will not solve all problems; additional services must be developed, especially so-called "soft support".

By this, we mean specialists who can advise on technology transfer, management, selecting a team, marketing, and so on. The country has a well-developed infrastructure of incubators and technology parks, but these lack specialised business and legal knowledge to support start-ups. And of course networking activities are also very important to start-ups. The search for the right partner to complement any missing competences in a team is an ever-present task for a company, especially in its growth phase.

A positive side effect of bringing technologies to market is the building of interdisciplinary teams that come together in the various phases needed in the commercialisation process. The validation process needs additional expert input; so does developing a prototype, developing a product/service for the end-user, the trial phase, and so on. With the opportunity to work together, new ideas and projects emerge, generating new knowledge.

Conclusion

As can be seen, there are more questions than answers to the issue of bringing knowledge to the market in the form of a new company. Nevertheless, activities should continue as the need to keep on creating a knowledge society demands nothing less than new jobs employing highly skilled people. The state educates them, and research possibilities are more or less provided for – so assisting in the creation of jobs for these smart people itself seems the smart thing to do.

Sources used:

- **VALOR EU project methodology (http://www.proinno-europe.eu/index.cfm?fuseaction=page.display&topicID=74&parentID=74#)**
- **Lenis Wound Care Ltd.**
- **Acies Bio Ltd. (www.aciesbio.com)**
- **Optilab Ltd. (www.optilab.net)**

Jasna Kontler Salamon
DELO

TALKING WITH Dr Janko Jamnik, director of the National Institute of Chemistry

"We are doing very well in all areas"

Today there are very few directors within Slovenian research, or outside for that matter, who have no reservations about admitting that they are very satisfied. Dr Janko Jamnik, the Director of the National Institute of Chemistry (NIC) belongs to this group.

More than one year has now passed since our last discussion. You were doing well then. Is this still the case?

It is. Our institute is still doing very well. In fact our results are continuously improving. This is true not only for our basic research, which is becoming more relevant as shown by publications in more prestigious journals, but also for our joint working on research with industry. In the latter area, we have begun to break down all barriers. We are marketing our inventions not only in Slovenia, but also quite successfully in Europe, which gives us great pleasure. Last year we acted as co-ordinators in three out of the eight consortia that were selected as centres of excellence. This is great recognition for NIC. We are doing equally well in the education. The NIC has a growing number of young researchers. With the young PhDs, it is particularly positive that each year, with the sole exception of last year, more and more are finding positions in companies.

In the field of Slovenian science and research, particularly in this period of recession, it seems almost a sin that a director of a research institute should be as positive as you are. You will have to have some very strong arguments in order not to be criticised. In any case, you will not be able to avoid envy.

I am not afraid of envy and my statement is supported by arguments based on solid facts. It is, however, true that the times are such that they could inspire fear. Nevertheless, verifiable facts show that the National Institute of Chemistry is successful – to claim otherwise would be false modesty. However, if we are objective and look over the entire Slovene research sphere, there are a number of reasons to be satisfied. Resources for science have grown substantially in the last year. This is a particular success for the ministry's current approach. The call for proposals for centres of excellence was also a sign of success. Despite the criticism, this is objectively an important success for Slovene science. It represents the first time that such a large amount of money was not distributed to a large number of small projects. For me, this is a very important qualitative leap in the financing of scientific research in Slovenia. And it is not the only example. We are very capable of obtaining

additional resources for stimulating the transfer of knowledge from research to the industry. Together with other institutions, the NIC took part in this call for proposals and was successful. In short, our common success is based on a number of factors, among them more substantial and better-directed state support.

Several interesting calls for proposals have been announced for this year as well. However, the period of European Structural Fund sources, which have allowed for the particularly well-funded calls of last year, is drawing to an end. What will follow is still not known. What does this mean for your institute?

Minister Golobič recently announced the possibility of a call for proposals for "Competence Centres". This should also be financed from European funds. Of course, sooner or later, this source of funding will run out and then we will need to shift our attention toward European framework programmes. Those capable and willing to do good work will always find opportunities.

You have said that your talk of success for the NIC is based on facts. What was the approximate increase in your income last year compared to the previous year? Did this also contribute to a growth in the number of researchers in full-time employment?

Firstly, on our employees, their number has been growing for several years. Last year, it grew by a few percent so that now we have close to 300 researchers. However, this growth is largely due to young researchers employed for the period of their doctoral study. The number of permanent positions has been the same for a number of years. Even in administration, as our employees retire, we replace them with new staff who are initially employed for a defined period of time. This is, of course, connected with the fact that we are a public institute, which additionally limits our flexibility in terms of staffing.

As far as our income last year is concerned, it grew slightly, by 6%, compared with 2008. Interestingly, income from industry decreased, but only by 3%. We see this as an important success, not only for the NIC but for industry as well. The decision by companies to invest substantially in development at a time when it is challenging to obtain money for salaries is certainly courageous. However, we have tried to make this easier for them as well. We have agreed to longer payment periods than initially foreseen, which has proven to be mutually beneficial.

Dr Janko Jamnik, the director of the National Institute of Chemistry (NIC)

How have you taken advantage of this windfall of income last year? Did the institute set itself any new goals for equipment modernisation or other large investments?

We are planning to double the investment into research equipment this year compared with last year. This does not include equipment that we will be able to obtain as part of the centres of excellence programme, which means that investment in research equipment will be several times higher than last year.

By definition, new equipment should bring new research and marketing opportunities. Are you expecting this to happen?

Of course. We are sure that this will happen. Perhaps with a slight delay, but it will happen. Looking at the past, we see that this has always been the case, all the more so because we take great care putting the equipment in the right place, with the necessary infrastructure and with people who know how to handle it. We have much experience of this and of late we have been working on making our equipment more accessible. All those who have completed the proper training can use our equipment. This is also true for people outside the institute, whether from academic institutions or industry. Those that have co-financed the equipment are entitled to equivalent time on the equipment, while others pay some compensation.

How does this openness function in practice? Are expensive pieces of equipment really fully utilised?

Yes, I can safely claim that is the case. We have an online reservation system, where everybody can see the occupancy of our equipment. The occupancy rate is very high.

Even at night?

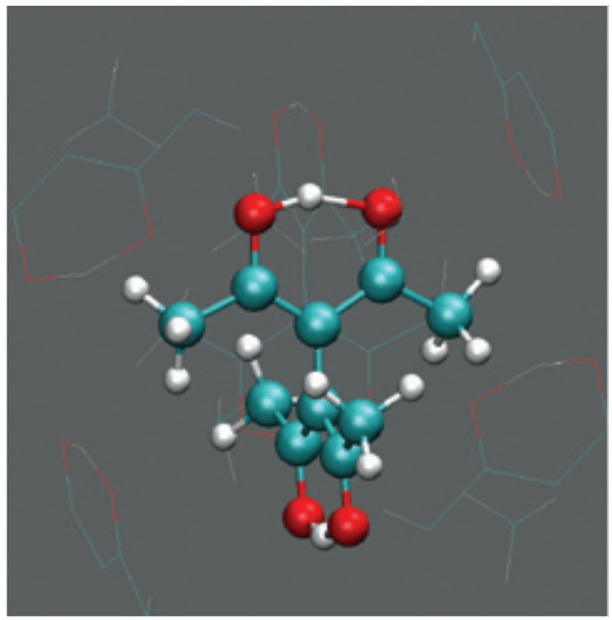
On certain pieces of equipment, sometimes even at night – if we count 4 am as night. And I do not mean only instruments that can carry out measurements by themselves. Certainly, some will ask themselves how this can be done. Several years ago, we started to move away from purchasing equipment alone and towards making purchases that include maintenance. Our tenders are often prepared so that the bidder must give a price for the instrument together with ten years of maintenance service.

This must be a better bargain…

Certainly. With this kind of purchase contract, we ensure that the equipment is inoperable only a certain minimal number of days during the year. If this limit is exceeded, we can charge penalties. This concept has worked well for us and has allowed more people to work on these sensitive instruments. We do not have to worry what will happen if it breaks.

Everything seems to be going well. Do you have any problems at all?

There is a continuously worsening space problem. Our people are packed so tightly that it is starting to make them nervous. Previous plans were to move the NIC from the city to Brdo, where they are developing buildings for the Chemistry and Informatics faculties, but this has not worked out.



Tetraacetyl ethane is a benchmark system with a short intramolecular hydrogen bond and represents a challenge for computational studies of the influence of a fluctuating periodic crystalline environment on the properties of the hydrogen bond.

Why did this option not work out?

It is difficult for me to say since this happened before I was in post. I do not know the full background. We now have only the option of building on site. We have one building that is old and unsuitable, and we wish to build a new one in its place. This would give us more space, which would also be of much higher quality.

Is this just a thought or is it already being implemented?

Last year, we carried out a public tender for the complete project documentation. At the moment, we are involved in an intensive discussion with the competent ministry on how to ensure financing for the replacement building.

It is not included in this year's investment plan.

That is correct, but we are in discussion for next year. It's important to realise that the state is the founder of NIC, so the decision is in the hands of the Government. We will, of course, assist within our capabilities. It is probably a good thing for the state to start construction at a time when the construction companies are having their worst time. Isn't it better to put money into investments rather than pay partial compensation for employees "on waiting"?

As far as connections with industry are concerned, is the NIC still mostly relying on the pharmaceutical industry?

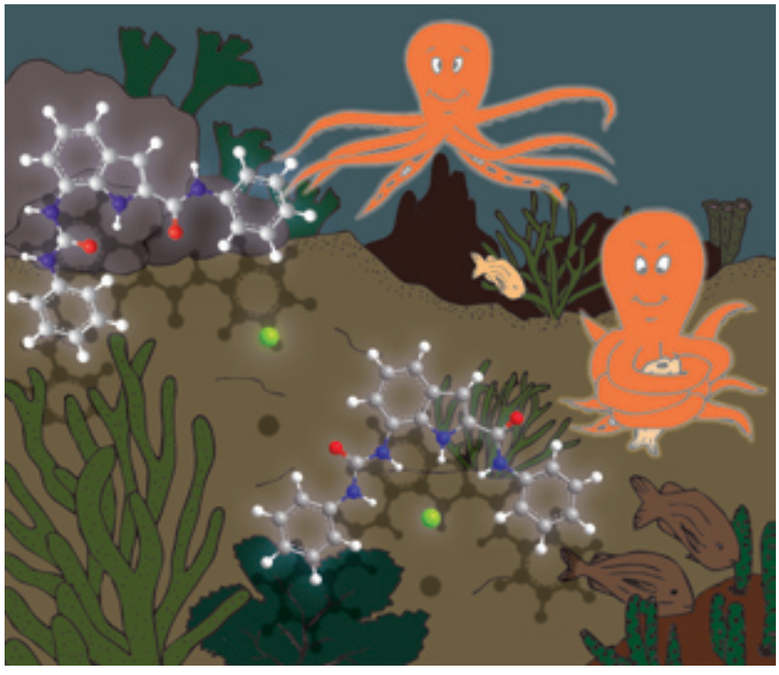
This sector is certainly still our most important partner. But recently we have been putting much effort into winning other industrial partners as well, so as not to be overly dependent on one sector. We also wish to widen our range of partnerships outside Slovenia. This will help us to spread risk. We see opportunities in those industries that use various advanced materials, produce coatings, and are active in low-carbon and other environmental technologies. We are gaining strength in all these areas.

You have mentioned the good marketing of patents. Are these also leading to the establishment of new spin-off companies?

In the area of selling patents and licences, the NIC is among the best institutions in Slovenia. Of course, we are still far behind the best institutions in the world. With spin-off companies, it is the exact opposite, since there are currently very few.

How do you explain this?

Slovenian legislation does not yet allow for establishment of spin-off companies in the same sense as elsewhere in the world. Within the given framework, we are therefore trying to find other equally successful methods for transferring technology to companies.



Conformational preorganisation and anion-induced conformational changes of indole-based receptors, studied by NMR spectroscopy

Licensing is currently showing itself to be the most successful solution.

But ministers keep claiming that it can be done and that there are already quite a number of such companies. Universities have them as well. Don't they have limitations?

Legislation in this area is quite complex, so establishing a company really isn't very simple. It is connected with a number of administrative limitations, necessary permits and approvals. The process takes a long time to complete and is not reliable. Due to ownership issues, it is even more so for public institutions that are not part of a university. Ownership is arranged differently for universities and public research institutions. Minister Golobič has already announced certain measures in this area, and, if they are passed, we expect that the motivation for enterprises of this kind will become much greater. For us, this is an additional reason to take part in the preparation of new research legislation.

Currently, the act and a new research and development programme are expected to be prepared by the end of the year. Is there anything else that you would like to introduce among the changes?

Mostly we wish that research institutions would become subjects in the true meaning of the word.

But you are legal subjects…

True, but not in the sense of content. We are still at the level of an agricultural co-operative. For example: ARRS (the Research Agency of the Republic of Slovenia) has contracts with the heads of programme groups and the NIC is more or less in the position of a formal signer of the contract. We would prefer that the agency distribute part of the money directly to institutes and then perform evaluations on the basis of the investment and the results achieved. Such is the practice around the world. Currently, institutes receive only basic (cold running) funds directly, representing 13% of our budget. This is a very small proportion.

You started the conversation with praise, but you are becoming increasingly critical…

I must be. You have said yourself that otherwise the research community will not look kindly on me.

Dr Janko Jamnik, who is 46, graduated from the Physics Department of the Faculty for Mathematics and Physics (FMF) of the University of Ljubljana. Three years later, he received his MSc from the same institution, and in 1994 he received his doctorate. During his doctoral study, and later as a researcher, he continued his training in Germany and the USA. He spent an extended period, almost five years, at the Max Planck Institute for Solid State Research in Stuttgart. He has been employed at the NIC for 22 years. Before becoming director of the NIC in 2008, he had been head of the Laboratory for the Electrochemistry of Materials since 2000. During his period in charge, the income of the laboratory tripled, while the income of the institute doubled

The Presentation of the Pregl Awards at the National Institute of Chemistry, 4 June 2009

Photo: Matjaž Omerzel

From the left: Prof. dr Janez Levec, Assist. Prof. Dr Maja Remškar and prof. dr Roman Jerala.

The Grand Pregl Award for research work was collected by SAZU academy member Prof. Dr Janez Levec, who is among the foremost researchers and educators in the field of chemical engineering, within Slovenia and the world.

Pregl Awards for outstanding achievements were received by Assist. Prof. Dr Maja Remškar, a pioneer of nanotechnology by both Slovenian and international standards, and by Prof. Dr Roman Jerala, for his innovative research approach in using and developing a wide range of methods from biochemistry and molecular biology in areas such as molecular immunology, the development of new medicines and synthetic biology.

The awards are named after Friderik Pregl, a chemist of Slovenian origin who was born in Ljubljana and won the Nobel Prize for chemistry in 1923. The aim of the Pregl Awards is to promote achievement and excellence in science and hence to contribute to the development of Slovenian society.

The keynote speaker at the event was the State Secretary of the Ministry of Higher Education, Science and Technology, Dr József Györkös.

Research activities at the University of Primorska

The University of Primorska was established in 2003 and is the third national university of Slovenia. The mission of The University of Primorska is to generate and transmit new knowledge, disseminating it through technological innovation, yielding training results in the wider Central European arena, and to support the development of creative experts and thinkers as a result of educational processes based on research, innovations and practical training.

The research activity of the University of Primorska is conducted especially at two research institutes: the Science and Research Centre Koper and the Primorska Institute of Natural Sciences and Technology, but also at the five faculties: the Faculty of Humanities Koper, the Faculty of Management Koper, the Faculty for Mathematics, Natural Sciences and Information Technologies Koper, the Faculty of Education Koper, the Faculty of Tourism Studies Portorož and also at the College of Health Care Izola.

In the past five years, 50 international and more than 100 national research projects have been successfully concluded at UP. Research activity at UP is increasing every year, which is seen in the number of project as well as in the increasing value of Full-Time Equivalent (FTE) points (which reached

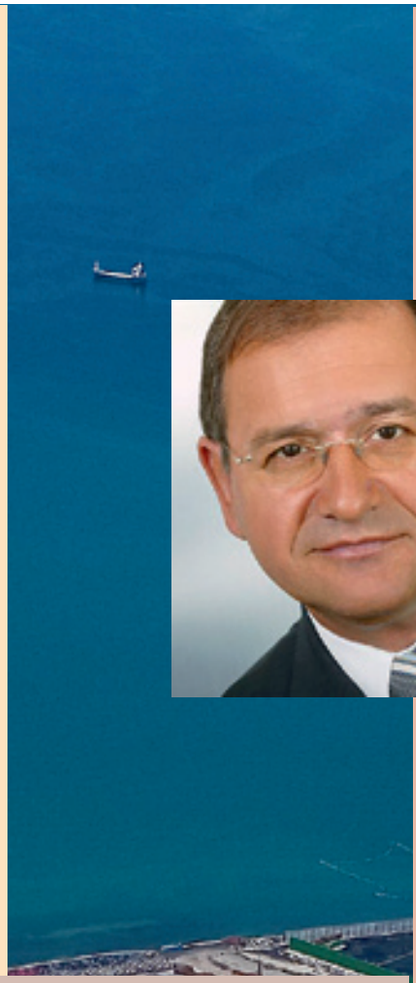
The Faculty of Humanities Koper

Dr Vesna Mikolič, Dean: "We are a modern faculty, where interesting and current topics in social sciences and humanities are taught in an innovative fashion. Its underlying principles, such as the excellence of study programmes, vigour, modern infrastructure and equipment, harmonious professional environment, professional progress and well being of students, as well as efficient networking within the university, Slovenian and international environment, guarantee the quality of its activities. The faculty is active in international research programmes and projects such as the IPA Slovenia-Croatia: Heritage Live (Living, lived, revived cultural heritage) project and the CBC Programme Italy-Slovenia: Jezik – Lingua (Multilingualism as wealth and value in the Italian-Slovenian cross-border area). Within the lifelong learning programme are the Bridge (Successful pathways for second-generation migrants) project, the Marina (Meeting the language and skills needs of coastal and river tourism workers) project, the Eunom (Promote education and reciprocal understanding through multicultural integrated teaching) project and Linguanet World Wide. Inclusion of research activities in the pedagogical process and improvement of study programmes is very important and the faculty works towards this mission in collaboration with the science and research centre and other institutions. The faculty also offers other study programmes for personal improvement, summer schools, courses and other forms of lifelong learning."

Photo: Jaka Jeraša

66.42 points in the year 2008). The basic research activity of the University of Primorska is conducted within 13 Research Programmes:

- Management, education, informatisation and employment
- Biodiversity
- Slovenia and the Mediterranean
- Areas of cultural contact in integration processes
- Kinesiology for quality of life
- Algebra with combinatorics and graph theory, probability and experimental economics
- Development and evaluation of new approaches to cancer treatment
- Animal health, environment and food safety
- Research, teaching and learning within modern society
- Computationally intensive methods in theoretical computer science, discrete mathematics, combinatorial optimisation, and numerical analysis and algebra with applications in natural and social sciences
- Metrology and biometric systems
- Management of sustainable manufacturing technologies
- Languages and cultures of Asia and Africa



The Faculty of Management Koper

Dr Anita Trnavčevič, Dean: "Our faculty is a higher-education institution for education and research in the fields of social sciences and business management, with a focus on management, which has interdisciplinary links to economic, business, legal, organisational and behavioural sciences. Along with education and research, the basic activities of the faculty are providing consultancy to companies and other organisations, publishing and library activities, and organising international conferences. The research activity of the faculty is closely embedded in numerous national and international research projects, in which it works alongside many domestic and foreign higher-education institutes and centres. It also works closely with organisations within the economy. The faculty is working on more than 60 research programmes and projects, 10 international programmes and projects, and more than 15 projects for economic and other knowledge users.

Rector's Foreword

The University of Primorska is a young and dynamic academic institution growing rapidly and facing constant challenges. Its youth is both an advantage and a weakness. The university cannot rely on a century-old tradition or long-established modes of operation. Yet this also allows us to react swiftly and adapt to the demands of our local and broader surroundings.

Prof. Rado Bohinc, Rector of the University of Primorska

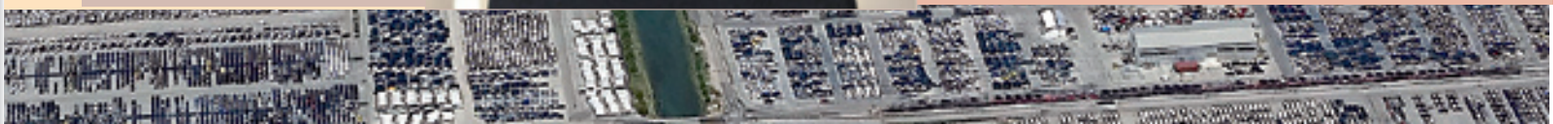
Our study programmes reflect the needs and specific nature of the Mediterranean region in which our university operates. Establishment of very close cooperation with economic and other users of knowledge is a special feature of our modus operandi. We are very much aware that research is the foundation for developing and further improving the teaching process, along with our relationship with the economy and local and broader community.

Ensuring the highest quality of teaching work, research, and human-resources development is therefore the fundamental goal of our University and the basis for building successful international partnerships and cooperation with higher education institutions within Europe and throughout the world.

We are also fully aware that an active presence in the international arena is an important platform for promoting the high quality of our greatest achievements and also a vital element in raising our profile in terms of international comparability with other universities. Co-operation with other institutions also adds the benefit of their experience and good practice to our own study programmes and research activities. The university, in its role as a harbinger of progress and creator of new knowledge for the advancement of society, is not merely a place for lengthy discussions of topics already addressed but much more a system for finding new answers to the question of what needs to be understood in the future.

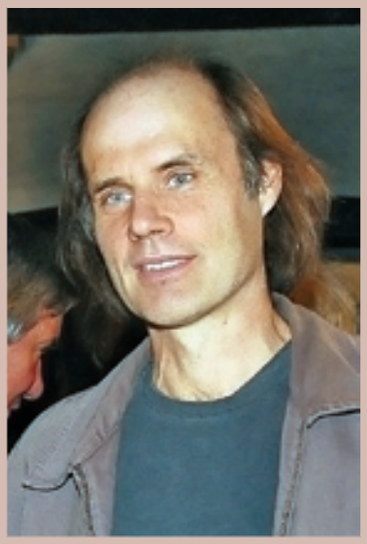
Last year we devised a new medium-term development strategy for the university (for 2009–2013). We made a commitment in this to act, in accordance with our values, vision, and mission, and also pledged to achieve our strategic goals. To quote the strategy, "the development of the University of Primorska in the coming years will be focused primarily on the quality and synthesis of generally accepted higher-education standards, the strengthening of balanced universality within the University and a further strengthening of the research and development basis, whilst respecting academic autonomy."

Quality in the sense of achieving excellence, attaining the highest and internationally comparable standards in teaching work and research, and also in all other fields of university operations, is one of our most basic values. This is why we have decided to reflect upon our orientation, our goals, and the means for their achievement, with the help of the Institutional Evaluation Programme of the European University Association. We see the evaluation by the European University Association to be completed in autumn 2010 as an important moment of reflection, which will enable us to improve our future planning process for academic growth and strategic management aimed at optimising all aspects of the university's operations.



The Faculty of Mathematics, Natural Sciences and Information Technologies

Dr Dragan Marušič, Dean: "Our faculty was established in 2006. Aiming to create a space of interdisciplinary interaction, the Faculty for Mathematics, Natural Sciences and Information Technologies offers undergraduate and postgraduate study programmes in computer science, biodiversity, bioinformatics, biopsychology, applied kinesiology, Mediterranean agriculture, mathematics, and mathematics in economics and finance. The faculty emphasises small teaching classes where modern teaching methods supported by recent advances in information technology go hand-in-hand with advanced scientific research tackling open question and problems in related disciplines, with the aim of achieving



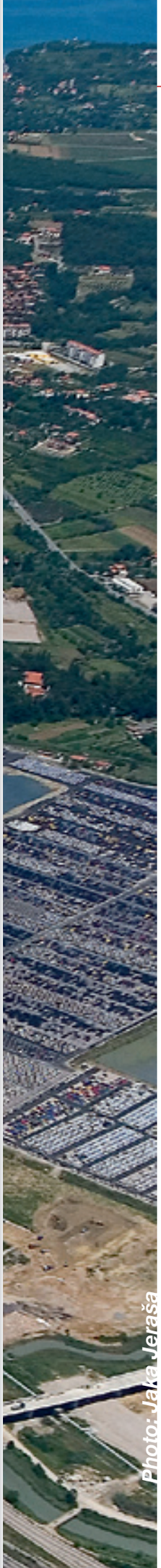
a stimulating teaching and research environment. Most research is carried out in partnership with the Primorska Institute of Natural Sciences and Technology. It is worth noting that one of the world's top three research schools in algebraic graph theory – a hot area of research in contemporary mathematics – has sprung from this jointly the Faculty for Mathematics, Natural Sciences and Information Technologies and The Primorska Institute of Natural Sciences and Technology research framework."

The Faculty of Education Koper

Dr Mara Cotič, Dean: "Within the university we have undergone tremendous development: since the establishment of the university in 2003, the number of students has increased from 390 to 1,150. The faculty continues with its tradition of supporting professional studies for pre-school educators, and primary and secondary school teachers. Within the faculty is the Research Institute for Educational, Informational and Mathematical Sciences, which brings together researchers in the area of human, social, natural and technical sciences as well the arts. The institute has also established connections with other domestic and foreign researchers, and is involved in national as well as international projects combining modern theoretical knowledge with pedagogical practice in its environment, e.g. the Partnership, Flachi, Cultural Awareness and Expression projects, an international summer school of systemic and functional linguistics, innovative and creative approaches to learning and teaching, etc."

The Faculty of Tourism Studies Portorož – Turistica

Dr Aleksandra Brezovec, Dean: "We are the first and only faculty in Slovenia that researches and teaches tourism in a multidisciplinary, integrated and practical manner. Within the faculty, a modern approach to studying tourism is used – Bologna I and Bologna II programmes, which are based on innovative education principles, active cooperation with the tourist economy and research into best practice within the profession. The faculty is aware that it is not enough only to teach; therefore a leading scientific centre for research into tourism is being developed. The faculty's researchers are the authors of the Development Plan and Policies of Slovene Tourism 2007–2011, which presents an effective development model for Slovenian tourism. The faculty can also boast many scientific achievements, for example The Best Paper Award CASYS '09, won by Tadeja Jere Lazanski, PhD, and the UNWTO Ulysses award for 2009 for special and innovative achievements in tourism for the Bank of Tourism Potentials project, designed by Dejan Križaj, MA, a research assistant at the faculty, in partnership with the Slovenian Tourism Organisation (STO) and the Directorate for Tourism of the Ministry of the Economy. The vision for the development of the faculty is to remain a central educational, research and development institution in tourism in Slovenia and, in the wider region, with high quality teaching, modern study programmes and with established partnership with other organisations in the field.



Dr Lucija Čok, University of Primorska, Science and Research Centre Koper

Unlocking the gates of languages

Lucija Čok

Every nation whose language is spoken worldwide is aware of the economic benefits of language-teaching policies. Since language skills are seen as human capital that gives individuals and companies an advantage in the market, it is not difficult to see a hidden trap in the spread of English or any other lingua franca. People with the potential to succeed, along with their managers, seem to encounter all kinds of cultural and linguistic barriers while other multilingual speakers succeed in the same market precisely because their use of language and communication enables them to be included in the other's world, its hidden intentions and methods of operation.

If "the limits of my language mean the limits of my world" (Wittgenstein, 19211), the use of every language expands my world and means more than just understanding the environment in which I live. It is possible to become so familiar with another environment that by entering another culture and another language we can change ourselves. Thus using a single, common communication language in addition to the original language opens up several worlds, and speaking languages other than English is therefore becoming increasingly important.

To enhance understanding of the need for multilingualism, under the auspices of the House of Lords a project entitled "Languages in Europe – Theory, Policy and Practice" was launched, with the aim of first and foremost promoting our own environment, and later also helping other countries to establish, maintain and promote linguistic diversity. Practical examples are used to support the professions and areas of education and research where competence in a foreign language is a requirement for success. The University of Primorska (UP) is one of the participants in this project. At a conference in London last April, the project vision was presented, both from the perspective of a linguistic researcher (Lucija Čok, UP Science and Research Centre) and that of a language user (Jan Hrvatin, a student of the UP Faculty of Management and UP Faculty of Humanities).

Dedication to the values that have shaped the lifestyle of the old continent is among the charms of the old and the challenges for the new Europe. Differences between managing the common European space and managing other global spaces can be found in the social and humanistic basis of European historical time and geopolitical space. This is where statehood and citizenship, transnational links, development priorities, beliefs and faith in values were formed. Today we return to the creation of political networks, economic integration, information links, which in the area of languages first and foremost address the networks of identities. The exploration of languages as the human potential of European societal and cultural diversity and human capital as European citizenship are two priorities of the action plans of the EU in various forms. The facets of European citizenship and its multiple identities as mirrored within different culturally bound concepts, the structures of the various ethnic groups forming the current European society, and the intrinsic cultural values generated by historical, social, political, economic, and other factors have to be analysed along the lines of notions transpiring through language, literature and similar expressions of culture, intertwining observations of a number of disciplines to give rise to new knowledge and understanding. To give an example: the inherent linguistic and cultural dimensions of South Eastern and Central Europe will allow universities and institutions at other levels of instruction to discern a distinct linguistic and cultural backdrop, revealing patterns of a historically and politically defined laboratory of European coexistence policy. The language variety, being defined as conditio sine qua non by world-wide language speakers is something new and encouraging for smaller or less used languages.

The research fields include issues pertaining to the field of linguistic anthropology, e.g. political correctness in communication, style distinctions (female/male) and hidden messages hinting at inequality between groups. Linguistic anthropology claims that the speaker cannot be discussed without taking into account the listener (the receiver of message) and his/her role in the speech act. Differences in speech styles, linguistic manifestations of feelings, the use of symbolism, metaphors, the role of artistic expression are all part of culturally bound traditions and signposts of intercultural communication. Creative use of language is another interesting research aspect, especially when coupled with cultural identity, ethnicity and citizenship studies. Efficient communication within a language community presupposes acquaintance with socially (and culturally) determined rules of verbal and non-verbal behaviour, which is even more the case for multicultural environments.

The executive branch of government can contribute to the rapid, efficient and financial development of linguistic diversity, equality and professionalism at national and international levels, provided it has the necessary political will and financial resources for research and implementation of results. In times of economic crisis, human capital is a means of effective enforcement of individual environments' comparative advantages – and multilingualism is certainly such an advantage.

[1] Ludwig Wittgenstein: Logisch-Philosophische Abhandlung, Wilhelm Ostwald (ed.), Annalen der Naturphilosophie, 14 (1921)

The Students' Residences

Leon Horvatič, Director: "Within the university we are responsible for providing accommodation for student and other participants in education. This represents an important social transfer, through which the state provides students with suitable housing.
Accommodation is available in Študentski dom Portorož, Dijaški in študentski dom Koper, Dijaški dom Portorož, Dijaški dom Izola, as well as in private residences and concessionaires in three coastal cities. The unit also refers students to Dijaški dom Nova Gorica and private residences in Sežana. Students are given priority on the basis of a credit system (financial circumstances, commuting distance and overall achievement), and in accordance with the Student Accommodation Subvention Rule. The development priorities in this area are expanding housing capacities and providing high-quality accommodation for all young intellectuals, students, teachers and researchers of the Primorska region.

The College of Health Care Izola

Dr Nadja Plazar, Dean: "We are one of the seven founding members of the University of Primorska. The college offers two undergraduate/first-cycle study programmes: Nursing (with a dislocated unit at Nova Gorica) and Nutritional Counselling-Dietetics, as well as the masters/second-cycle study programme in Nursing. In the academic year 2010/2011, a joint second-cycle study programme in Management of Sustainable Development will be implemented (in partnership with the Faculty of Management and the Faculty of Humanities). The college is also a recognised research organisation. There are currently two research programmes in progress (Animal health, environmental and food security and Development and evaluation of new therapies for malignant-tumour treatment), two basic research projects (Detection of prosthetic infection at revision arthroplasty and Combination of electrogene immune therapy with interleukin-12 and irradiation for treatment of experimental tumours) and one applied project (Cell-free nucleic acids in diagnosis of coronary atherosclerosis), funded by the Slovenian Research Agency. At the international level, the college is involved in the MNTERANET project. Research work mainly covers the following areas: cardiovascular diseases, oncology, orthopaedics-prosthetics, dietetics, nursing, care of the elderly, etc. The College of Health Care Izola is a place where views are shared, knowledge and understanding gained, and a spirit of lifelong friendship and comradeship felt.

The Science and Research Centre Koper

Dr Darko Darovec, Director: "We operates, on a distinctive interdisciplinary basis (combining studies in the humanities and the social and natural sciences) and lay particular emphasis on research of topics related to the Mediterranean and the Upper Adriatic area. Its core activities are basic and applied research, preparation of expert studies and counselling, education, organisation of scientific and professional meetings, publishing, documentation and librarianship. The centre is an active player in the international scientific arena, working in partnership with similar foreign institutions. The centre's researchers also take part in educational processes at all three Slovene universities, thus allowing for the dissemination of findings and research results to the educational field. The centre comprises the following organisational units:

Scientific and research units i.e. institutes, conducting research programmes, basic, developmental and applied research commissioned by public institutions and companies, professional analysis and counselling, training young researchers, and educational activities in the relevant subject fields:

1. Institute for Mediterranean Humanities and Social Studies
2. Institute for Biodiversity Studies
3. Institute for Mediterranean Agriculture and Olive Growing
4. Institute for Mediterranean Heritage
5. Institute for Linguistic Studies
6. Institute for Historical Studies
7. Institute for Kinesiology Research
8. Institute for Geographical Studies
9. Institute for Corporate and Public Law

Infrastructural units providing professional and technical support to the scientific and research units (Annales Publishing Unit, Centre for Economic Co-operation, Public Opinion Centre, Laboratory for Physical and Chemical Analysis, IT Centre, Libray, Centre for Environmental and Spatial Research, Olive Oil Testing Laboratory."

The Primorska Institute of Natural Sciences and Technology

Dr Štefko Miklavič, Director: "Our institute was founded in 1999. It became a full member of the University of Primorska in 2003. The main area of the institute's work is research and development in the fields of science, engineering and health care. There are three closely connected interdisciplinary departments within the institute. The Department of Mathematics and Computer Science works mainly in the areas of algebra, combinational mathematics and graph theory, probability theory, data structure, data mining and other fields. The department is actively involved in the area of service and GRID and other distributed computing architectures, and, through mathematical modelling and computer simulations, also in the area of experimental economics and social-systems research, e-security and pattern recognition (speech recognition). The Technology Department is focused on protecting the environment, especially measuring air pollution and developing new methods and technologies for use in this monitoring. The Department of Health Studies was founded with the mission of becoming the leading research body in the region for public health with special emphasis on mental health, e-health and health tourism. Its researchers are improving their knowledge in the areas of alcohol-abuse prevention, the genetics of suicide, treating young people, etc. The Faculty for Mathematics, Natural Sciences and Information Technologies is also integrated in The Primorska Institute of Natural Sciences and Technology's research and development activities. This close partnership assures immediate incorporation of students in research and development work. The institute and the faculty attract numerous Slovenian and international students, researchers and visiting professors from abroad (China, USA, Europe). By integrating these in research and teaching at the same time, the Primorska Institute of Natural Sciences and Technology and the Faculty for Mathematics, Natural Sciences and Information Technologies become stronger parts of the shared European and world-wide educational and research environment. Through its research, the Primorska Institute of Natural Sciences and Technology represents an important partner in the Primorska area, as well as in the Slovenian and international environment. The institute is actively working on several national and international projects within both the scientific and research field and the economic field."

Applied Humanities for Regional Development:

Three projects about Istra

Darko Darovec, Aleksander Panjek

In the past few years, the Science and Research Centre at the University of Primorska (UP SRC) has invested significant efforts in developing knowledge and competencies in the field of applied humanities. It hardly needs saying that the human sciences are generally regarded as fields that hardly produce concrete research results that may be applied and realised. On the other hand, consciousness of the need to develop and enhance the potential of human sciences in application are very present. A significant sign of this orientation is represented, among others, by the HERA (Humanities in the European Research Area) programme that in 2009 launched the HERA Joint Research Programmes (HERA JRPs) on "Cultural Dynamics" and "Humanities as a Source for Creativity and Innovation". These efforts are, in our opinion, also very important with regard to the education process and to university students in humanities, since the ability to apply knowledge may offer relevant additional employment opportunities. We furthermore firmly believe that, with such an approach, universities may offer a relevant contribution to regional development, since humanistic knowledge can only help in properly promoting the cultural resources of a territory.

At the UP SRC, we are developing this knowledge and these competences especially in the field of cultural heritage promotion, in particular connecting historical and archaeological knowledge to the enhancement of tourism potentials. The institutes that contribute most to this development are the Institute of Historical Studies and the Institute for Mediterranean Heritage. We will present three examples of projects in this field, but we would also like to stress that, based on the experience gained so far at the University of Primorska, we have also developed a master-degree study programme in Heritage Tourism, in partnership with the Faculty of Tourism Studies and with the Faculty of Humanities at our university, which will start in the academic year 2010–2011.

Carnival in Rakitovec Slovenia HERITAGE LIVE

The projects we will briefly present here are cross-border cooperation projects in which the UP SRC acts as lead partner, and were mainly developed at the UP SRC from the stage of the idea to the implementation of the project, with the necessary cooperation of the other project partners, of course. The focus of the projects is the Istrian peninsula. Visitors to Istria, lying on the warm shore, and staring at the crystalline sea, may not, for the most part, think about the cultural treasures hidden right behind their backs, in the interior of Istria. And yet cultural heritage is among the most important factors that form the identity and ability to identify a certain place or country, while at the same time representing a basis for culture and nature-friendly forms of development, especially in the area of cultural tourism. In the last century, tourism has become an important economic field in Istria and is based upon a pattern of mass sun/sea bathing-tourism, which has led to a focusing of the tourist provision and of employment opportunities on the narrow coastal belt and the summer months, but which has neglected cultural heritage as well as potential tourist destinations in the interior of the peninsula. Such development has, over decades, contributed to migration from the surrounding areas to the coastal cities and towns and to the subsequent under-population of the countryside, abandonment of agriculture and consequently to the degradation of the traditional cultural landscape. On the other hand, cultural and historical elements have intertwined throughout Istria over the centuries and continue to do so today. These elements have helped shape its complex and rich cultural heritage. On this basis, it is possible to assert that Istrian cultural heritage represents a potential source of tourist development.

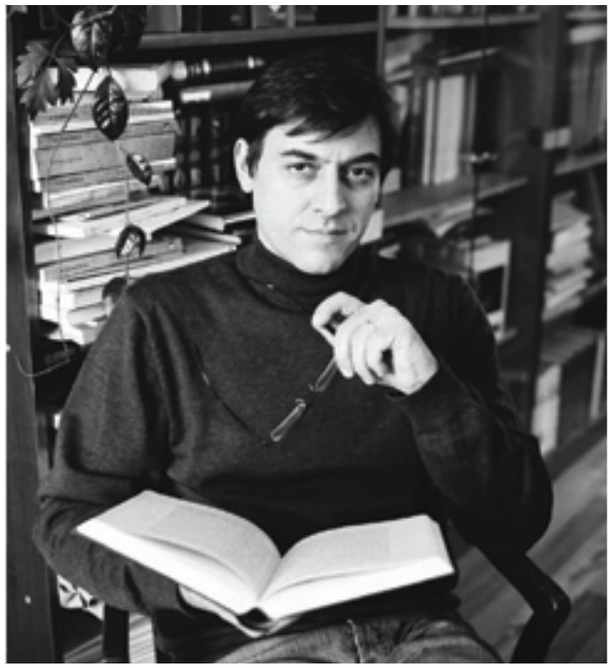
The project HEART OF ISTRIA – Heritage and Art. Development of Cross-Border Tourist Itineraries in Urban and Rural Areas of Istria, (INTERREG III A, Neighbourhood Programme Slovenia-Hungary-Croatia; project manager Darko Darovec) running in the years 2005–2008, arose from these considerations and represented a kind of a test, if not a challenge, on how to develop practical applications for studies in the humanities and to demonstrate how to apply humanistic knowledge. The project is moreover based on the idea that cultural tourism could open new possibilities to the local population, as well as to visitors, as it could help to bring tourists year-round and throughout the whole territory of Istria. The project also arose from the awareness that, for this purpose, it is necessary to better promote Istrian cultural heritage, and that it is only possible to do this based on knowledge of its cultural content and history. This is where researchers can contribute new findings. The project HEART OF ISTRIA, led by the UP SRC and Istria County in cooperation with the municipalities of Koper, Izola, Piran and Buzet, boasted cooperation between the scientific and educational institutions and the local communities, and attempted to contribute to the development of cultural tourism in Istria, with the help

of scientific and professional promotion of its cultural heritage. With better knowledge of its long history and the value of its cultural heritage, the local publication can better recognise opportunities for the development of different forms of cultural tourism and thus become more active participants in the sustainable development of the countryside. Contemporary forms of cultural tourism could, at the same time, attract new types of guests, who would visit the coastal towns, as well as the interior Istria and its surrounding areas.

One other feature of the project was approaching Istria as a cultural-historical entity regardless of the past and present division of its territory among various different countries, thus attempting to strengthen the awareness of the local population, as well as foreign and domestic visitors, regarding all the nationalities present locally and about the common historical heritage of the region. Even in the planning stage of the project, a question presented itself with regards to the problem of which common contents we should choose from the diverse cultural heritage of the region, which is enriched by integration into different European intellectual, artistic and also economic currents, as well as by the intertwining of disparate historical influences, reaching back to the old Histers and Romans, to the Byzantines, Venetians and Habsburgs, all the way to the modern Slovenes, Croats and Italians (to mention only a few of the most well known). The selection was by no means easy, not because of a lack of common cultural features, but rather the reverse, that is, because of the rich possibilities of choice. This proved especially true as we considered the contemporary notion of cultural heritage as composed of both material and immaterial heritage, thus ranging from great monuments to popular rituals and the material culture of everyday life. We tried to select thematic routes to connect well-known monuments and destinations with those that are less famous, the coastal towns with their surrounding areas and the countryside. Among all the possible common, connecting cultural contents of the Istrian territory we have chosen four, and on this basis conceived four cross-border tourist itineraries: Urban Istria, Fortified Istria, Istrian Frescoes and Ancient Istria. The results of the project were also published on the Internet (see: http://heartofistria.org/).

With the project HERITAGE LIVE – Living, Revitalised, and Lived Heritage: Project of training in the field of recognition, preservation and presentation of cultural heritage of the Slovenian-Croatian cross-border area (IPA Cross-border Cooperation Programme Slovenia-Croatia 2007–2013, project manager Aleksander Panjek), being implemented 2009–2012, we decided to focus our attention on the immaterial cultural heritage in particular and on the application of contemporary IT tools in the field of heritage preservation and presentation. The partners in this project are the University in Zagreb, the Associations of Archivists of Slovenia and of Croatia, and the municipalities of Koper, Izola, Piran, Umag, Buje and Lanišće. The HERITAGE LIVE project objectives are to support the preservation and revitalisation of cultural heritage and thus strengthen identity, to strengthen and develop knowledge and capacities for heritage preservation, revitalisation and presentation, to develop the synergetic effects in the joint promotion of common cultural heritage, to strengthen intercultural exchanges, mobility of experts and artists, and cross-border cooperation and to support the inclusion of cultural heritage among assets for the development of the cross-border area. In doing so, the project has created the conditions for improved use of cultural assets for sustainable development of the cross-border area, it supports local actors who are rebuilding the cultural and social ties in the border region, it supports cooperation in the fields of cultural services between civil society organisations, municipalities, and educational organisations, and it provides support to the common cultural heritage of the border area and joint efforts to identify, preserve, restore and portray the common cultural heritage of the region. The added value of the project is in a higher rate of integration of common material and non-material cultural heritage into tourist provision, in new tourist products and in the promotion of the entire cross-border area as a tourist destination in new forms and with improved products and services and better use of natural and cultural resources, which will ensure new sources of income in the rural areas. There is also the opportunity for the local population to take an active part in cultural and tourist activities, since the results of the project present a platform for independent and creative activity of residents in the field of promotion of traditional and authentic elements of cultural heritage in the cross-border area.

Knowledge exchange between experts on both sides of the border and closer cooperation between cultural, tourist, scientific, educational and administrative institutions will help establish a closer cross-border connection into a joint tourist area. The project comprises two thematic pillars: the development of an international PhD study programme on Heritage Management with Information Tools, with which we respond to a specific need expressed by Slovenian archivists, and the definition of guidelines on “authenticity” in cultural tourist provision in Istria for local communities and organisers of “traditional events”. The HERITAGE



Dr Darko Darovec, University of Primorska, Science and Research Centre Koper.

Dr Aleksander Panjek, project manager of HERITAGE LIVE, University of Primorska.

LIVE project outputs will be a study on Heritage Management with Information Tools, a manual, workshops, excursions, an international PhD study programme in partnership with the University in Zagreb, archivist meetings, conferences, and a website.
The most recent project we would like to mention here is SHARED CULTURE – Strategic project for knowledge and accessibility of shared cultural heritage (Cross-Border Cooperation Programme Slovenia-Italy 2007–2013, call for strategic projects' project manager Darko Darovec), in which the shared cultural heritage deriving from the period of the Republic of Venice represents the common feature that will be presented and promoted. The partners in this project are the University "Ca' Foscari" in Venice, the University of Udine, the Veneto Region, the Institute for the Protection of Cultural Heritage of Slovenia, the Municipality of Koper and the organisation representing the Italian minority in Koper. Within this project, we will restore a historical palace in the old city centre of Koper (Baseggio palace), that will become the seat of the Inter-university centre for Venetian history and cultural heritage, founded in partnership with the University "Ca' Foscari". This project aims to contribute to overcoming persistent incomprehension between the populations of Slovenia and Italy regarding their (shared) history, by stressing one very important common historical trait, such as the Venetian Heritage. Within SHARED CULTURE, activities such as data collection, document collection and digitisation of historical studies, scientific conferences and public events, as well as publications will be carried out, along with the renovation of the historical palace, the activation of the inter-university centre, and research on two important sites at the origins of the city of Venice: Altino and Concordia Sagittaria.

Baseggio Palace in Koper SHARED CULTURE

Carnival in Petrovija Croatia HERITAGE LIVE

HIC – Heritage Information Catalogue

Aleksander Panjek, Katharina Zanier

The system HIC – Heritage Information Catalogue represents the result of the Applied Research Project Information Database of Natural and Cultural Heritage of the Slovene Mediterranean (2007–2009), financed by the Slovenian Research Agency and carried out at the Science and Research Centre at the University of Primorska (UP SRC). The project manager was Prof. Dr Aleksander Panjek (Institute for Historical Studies) and the interdisciplinary project team was composed of members of different institutes of the UP SRC.

The aim of the project was to establish a pilot system for integrated cataloguing of natural and cultural heritage with the use of geographic information systems (GIS). By the end of 2009, the prototype of the database was completed with the implementation of selected cultural and natural heritage contexts from the Primorska region (a beta version of the database with restricted access).
The web-based Heritage Information Catalogue called HIC ("hic" = Latin "here") – a name that makes clear the topographical orientation of the database, which aims at highlighting the natural and cultural resources surrounding us – enables standardised capture and entering of different kind of records from the fields of natural sciences and humanities. The main objectives of the database are:
- cataloguing and documenting natural and cultural heritage contexts and items;
- storage, management and manipulation of information, bibliographic/archive references and digitised multimedia documents (text documents, images, videos, sound recordings and applications) related to the recorded contexts and items;
- cartographic evaluation of the recorded natural and cultural heritage contexts;

- dissemination of knowledge about the rich natural and cultural heritage of Slovenia and it promotion.

Specifically, the online catalogue is designed to collect data related to areas of geomorphologic, geological, hydrological, zoological, botanical, dendrological and ecological interest, as well as natural heritage collections (natural history museums, herbaria, botanical and zoological gardens, etc.), cultural landscapes, archaeological sites, architectural and urban monuments, expressions of intangible cultural heritage and cultural heritage collections (museums and other public and private collections of cultural heritage items), providing access to descriptions and interpretations of the contexts and of the objects or items related to them, information relevant to the preservation, monitoring and management of the contexts, bibliography and archive sources, topographical information, visitor information and data-entry information. Record sheets will be connected to a gallery of digitised documents (text documents, images, videos, sound recordings and interactive virtual-reality reconstructions) and will also show links to related sites. The cartographic representation (GIS) will allow not only to visualise the location of the recorded areas, sites and buildings, but also the distribution of specific information related to the contexts, such as heritage typologies, categories and definitions, specific characteristics including building techniques and decorative elements. For these characteristics, HIC will be unique both on the national and international level: a few informative systems already exist, in Slovenia, such as the Atlas okolje (http://gis.gov.si/atlasokolja/profile.aspx?it=Atlas_Okolja_AXL@Arso), the Register nepremične kulturne dedščine (http://rkd.situla.org/), the Arheološki kataster Slovenije (http://arkas.zrc-sazu.si/) and DEDI – Enciklopedija naravne in kulturne dediščine na Slovenskem (www.dedi.si), but, as is evident by their names, these represent inventories more than catalogues, and in the very synthetic character of the reported metadata, they seem to be more useful for administration purposes than for research and promotion of Slovenian heritage. In other countries, natural and cultural heritage are split into different catalogues, impeding combined analysis and promotion of these areas. The integration and combination of the implemented information allows better understanding of synchronic and diachronic dynamics involved in the development of cultural phenomena, as well as integrated policies for the protection of natural and cultural heritage (and as an aid for planning) and for its management and promotion, highlighting the entire range of resources of the study area. The Heritage Information Catalogue will therefore for the first time provide easy access to information, digital documents and bibliographic/archive references related to both natural and cultural heritage and their cartographic representation, as well as flexible recording and documenting of natural and cultural resources, which can be continuously modified, updated and increased, always referring to the newest results of scientific research, by reproduction of a universal museum composed of different kinds of information and documents into the virtual space, which will offer the visitor interaction, flexibility of paths and ubiquity, as well as the simultaneous use of different media channels.

HIC will be useful for research, conservation, monitoring, management and promotional purposes, as well as for education and tourist/visitor information. It will provide an improvement of research activities, education, protection and conservation, management and promotion in the fields of natural and cultural heritage, increasing the visibility of Slovenia, by offering to the widest number of people around the world access to communication and information networks in the fields of natural and cultural heritage of the region, and thus help to promote a Slovene heritage identity, to spread the awareness of territorial protection, and to enhance sustainable development

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Properties of mass concrete for construction of the arch dam at the Sveta Petka Hydro Power Plant in Macedonia

Matjaž Goltes, Matjaž Kumelj, Tomaž Škoberne, Jure Korla, Jakob Šušteršič

Keywords: arch dam, mass concrete, heat of hydration, large-aggregate concrete

Abstract: In this paper, the arch dam project at the Sveta Petka Hydro Power Plant (HPP) in Macedonia is briefly described. Emphasis is placed on the design requirements, such as the use of large-aggregate concrete, a low water-cement ratio, flexural tensile strength and strict restrictions on the temperatures of fresh concrete and the internal temperature of hardening concrete. The coordination between the designers' requirements and the contractors' proposed solutions is described, and some of the adopted solutions are presented.

Jure Korla

INTRODUCTION

Hydraulic structures represent an area of great significance in civil engineering. Construction is usually carried out under demanding conditions (presence of water – river-bed, lack of space) and exceptionally rigorous requirements of construction quality (given the potentially catastrophic consequences that could result from failure).

Designers of these structures are obliged to take into account the loadings, in addition to other parameters, which derive from heat relaxation during the hydration of the cement in the concrete.

Construction of such structures is not common in practice, and therefore challenging problems can always be anticipated at the beginning of such a project. In the paper, we shall try to describe the characteristic difficulties that arise during construction of such structures in general, as well as those that occurred during construction of the arch dam at the Sveta (Sv) Petka HPP in Macedonia.

Jakob Šušteršič

Matjaz Goltes

Riko, the Technological Equipment Supplier

Janez Škrabec

Riko is a global engineering company, specialising in the planning and execution of projects in the supply of technological equipment and power, the environment, logistics and construction engineering. Riko's excellence in these fields are as a result of its considerable expertise in the countless peculiarities and foibles that arise in the field of engineering. Close attention is devoted to the issues of environmental responsibility, efficiency, design and other aspects of contemporary engineering.

Operating on a global project management level is the key goal of Riko d.o.o. (Ltd.), a technological equipment supplier for various industries, and a leader in the fields of industrial engineering, construction, transport and storage systems, energy, ecology and wood construction – from planning to execution.

Riko has business activities in the Russian, Belarusian, Ukrainian, Macedonian and EU markets. Despite its global orientation, Riko is also focused on thoroughly understanding and satisfying local market requirements and the specific needs of its partners. Riko's agencies in Moscow, Minsk and Kiev offer direct support to its clients, employing its experts directly from the local community.

Drawing on its wealth of experience, Riko undertakes complex automated processing projects in a comprehensive manner, providing complete technological equipment solutions from planning to execution. Due to its versatility and ability to compete, Riko has established itself as a supplier to automotive companies, and, through its knowledge and experience, is in the process of developing an efficient logistics system in the furniture and goods transportation industries. In addition to this, Riko has an enviable reputation in the automatic high-shelf warehouse sector, through its work with the world-renowned Swedish furniture manufacturer, Ikea, which boasts the largest automated warehouses in the former Soviet Union – the Ljubljanske mlekarne and Kovinoplastika Lož high-shelf warehouses. In the planning and execution of investment projects, as well as in the organisation, coordination and management of construction, installation and renovation works, Riko is a renowned player in the field of energy sector investments. A case in point would be the building of the Macedonian HE in Sveta Petka, led by Riko from planning to execution. The company also advises on, plans and executes investment projects in the areas of power, road and railroad infrastructure engineering. Riko can execute the most demanding construction projects, ranging from new developments to renovations, always maintaining the highest quality. Its vast experience and excellent reputation place it among the most sought-after companies in the world for planning and execution. One of the projects it prides itself on most is the construction of the Peter Ist Hotel in the centre of Moscow. It also lays a proud claim to having participated in the construction of a 200-wooden-house settlement in the Cotswolds, England, designed in partnership with celebrated designers, Philippe Starck and Jade Jagger at Yoo Studio. In 2009, Riko started a new collaboration with Philippe Starck, designing and manufacturing houses under the joint brand "Starck with Riko" from start to finish. In the field of ecology, Riko maintains the tradition of communal equipment manufacturing, which is enhanced with engineering services and project management from planning to execution. Also noteworthy is the construction of the municipal waste-water treatment plants in Trbovlje (Slovenia), Skopje (Macedonia) and the leached-water treatment plant at the Ljubljana Barje dump.

As a result of their knowledge, experience, quality and market penetration, Riko managed to become one of the most in-demand providers of engineering services in Eastern and South Eastern Europe, with high recognition at home. According to research conducted by Kline & Company in 2009, Riko was ranked the 28th most respected company in Slovenia, and its manager the 6th most distinguished leader among Slovenian managers during the same period. In 2002, the honour of "Rating leta 2002" (Rating of the Year 2002), was awarded by Bonitetna hiša I d.o.o. poslovne informacije company to both Riko and Dun & Bradstreet, the largest company in terms of profit in the world. Every year, Riko attains an A1 profit grade and its quality management standards regularly meet the requirements for ISO 9001:2000.

Janez Škrabec, Direktor

Riko's success stems from values integrated into a system that respects, develops and supports creativity and employee fulfilment; these values assist employees in their personal development and their creative roles within the team, as well as supporting their educational requirements and ambitions. The main company goals are, of course, consumer satisfaction and successfully completed projects, which further serve to create closer ties among those involved. Continued growth, which has helped Riko conquer new markets since its establishment, is both the goal and consequence of its professionalism and endeavour. It also represents a challenge to the company's philosophy, which pledges the prevention of adverse environmental impacts in the course of its work and to support socially important, cultural and other factors, which are crucial for the positive development of all.

Dr Andrej Zajc

Tomaž Skoberne

Matjaž Kumelj

The IRMA (Institute for Research in Materials and Applications)

Andrej Zajc

The Institute was established in November 1992 with the intention of becoming the expert body in the technology of the production and use of cementitiously-bonded materials. In January 1993, the Ministry of Higher Education, Science and Technology formally acknowledged the IRMA as a result of their members' references to it as a research and development organisation.

In 2000, the IRMA's laboratory was accredited for the testing of concrete, aggregates, mortars, concrete products, masonry units, and some products and systems for the protection and repair of concrete structures by Slovenian Accreditation in accordance with the SIST EN 45001:1999 standard. After some years, the quality control system in the laboratory was supplemented to fulfil the demands of new edited standards for quality control in laboratories, SIST EN ISO/IEC 17025:2002 and SIST EN ISO/IEC 17025:2005.

In 2004, the Ministry of the Economy appointed the IRMA as a certification body for some further construction products. As such, in 2005, the IRMA's laboratory was also accredited for the testing of concrete, mortars, aggregates, masonry units and some precast concrete products by Slovenian Accreditation in accordance with the SIST EN 45011:1999 standard.

Since the establishment of the IRMA, its role in the market has been as a technological centre and support network for its clients, advising on the erection of new – as well as the repair of old or damaged – constructions and buildings. Due to its know-how and vast experience in the technologies of production and use of cementitiously-bonded materials, the IRMA not only carries out technical supervision of the most delicate concrete constructions, but also provides expert advice on concrete technology and assists in the solution of problems related to its construction. In the last 15 years, the IRMA was present at all the hydroelectric power plants constructed in the Republic of Slovenia.

INFORMATION ABOUT THE SVETA PETKA HPP

The project was partly financed with proprietary funds from ELEM – Macedonian Power Plants, and partly from a loan for the civil works and equipment.

In December 2007, the first phase of construction was finished, including the access road, diversion tunnel, overflow shaft, bottom outlet and cofferdams.

In January 2006, the contract for the second phase of construction (including design) was signed with the company RIKO in Ljubljana. The designer of the dam was Energoprojekt – Hidroinženjering Consulting Engineers Co. Ltd. from Belgrade, Serbia.

The Sv Petka Hydro Power Plant (HPP) (previously called Matka II) was the missing link in the optimal use of the hydropower resources of the Treska River. The site of the HPP (Figure 1) is located between the new Kozjak HPP (about 16 km upstream from Sv Petka) and the existing Matka I HPP, situated downstream.

The main purpose of the Sv Petka HPP, as part of the multipurpose Skopsko Pole hydro-system – Kozjak-Matka subsystem, is to utilize the available hydro potential of the Kozjak HPP discharge and the local waters in the Treska River catchment area between the Kozjak HPP and the Sv Petka HPP dam sites.

Other than the above purpose, with the useful area of the Sv Petka HPP reservoir and available useful area of the existing Matka reservoir, the continuous regulation of daily Kozjak HPP discharges should be enabled according to the needs of other water users downstream of the Matka HPP (water supply, irrigation, biological minimum and other needs).

Figure 1: Site of the Sv Petka HPP

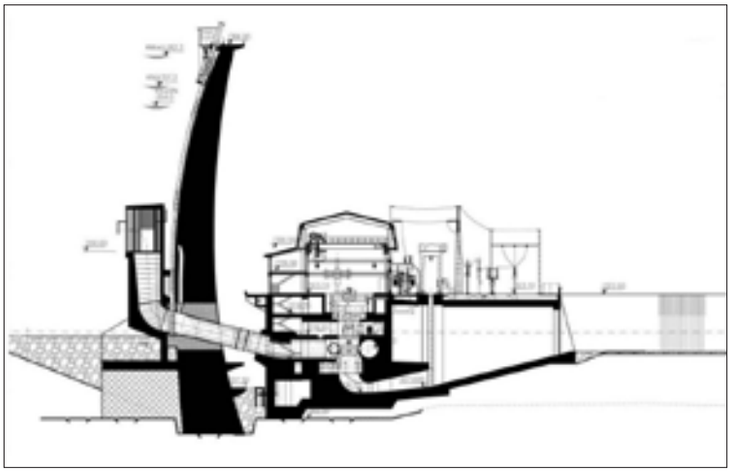

Figure 2a: Cross section (1 – 1) of the dam and powerhouse

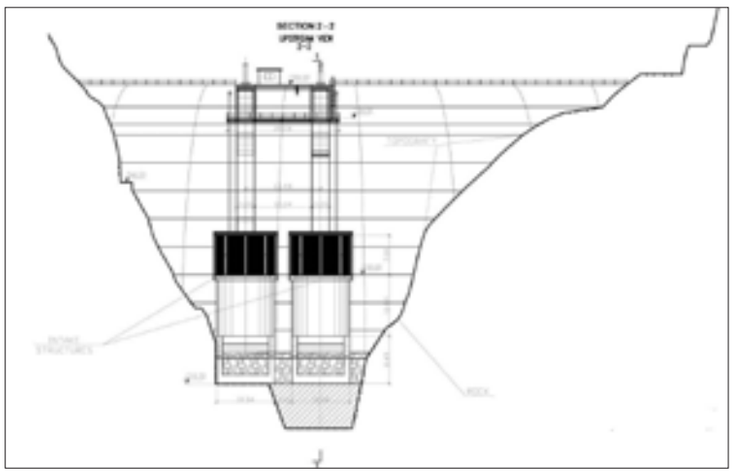

Figure 2b: Upstream view of the dam

In the Treska River cascade, the Sv Petka HPP will operate using the discharge water from the Kozjak HPP as a kind of run-of-river power plant, but during the day, using the storage capacity, it will also maintain the constant flow of the river downstream from the cascade. The Kozjak HPP and Sv Petka HPP, with a total capacity of 116.4 MW, will contribute to the reliability of the electric power system.

The dam was designed as a double arch dam, with a height of 69 m, a crest length of 118 m, crest level at 364 masl and a concrete volume of 24,600 m^3 (Figure 2a, b).

The reservoir will cover a surface area of 0.54 $(km)^2$ at a minimum operating level of 355 masl and a maximum surface area of 0.62 $(km)^2$ at a maximum level of 357.3 masl. Its total storage volume is 9.1 x 10^6 m^3, with an active volume of 1.1 x 106 m3. The length of the reservoir is 11 km along the Treska River.

The installed capacity of the power plant is 36.4 MW. It comprises two Francis turbine units of 18.2 MW each. The design flow through the turbines is 2 x 50 m^3/s.

MASS CONCRETE

Project requirements [1]

Large-aggregate concrete with a maximum corn diameter (D_{max}) of 100 mm was specified by the designers for construction of the main part of the dam. Concrete with Dmax = 64 mm is required for a smaller part of the dam (the reinforced part around the pipeline). The top of the dam will be constructed using concrete with Dmax = 32 mm.

Use of cement with a strength class of 35 MPa and with the addition of 15–35% pozzolan was required for all concrete used in the dam. The maximum allowable heat of hydration of the cement had to be 56 cal/g (234.3 J/g) after 7 days. The specific surface of the cement according to Blaine is limited to 3500–5200 cm2/g.

The cement quantity in the concrete was limited to 250–280 kg/m^3 at a water-to-cement ratio of 0.45–0.50. The initial temperature of fresh concrete was limited to 10–20°C, while the temperature of hardening concrete inside of a block was limited to 40°C.

Project requirements of hardening concrete at 90 days were:

- ◊ compressive strength – strength class of 30 MPa (MB 30; C25/30); compressive strength determined on a 30-cm cube (for concrete with D_{max} = 100 mm)
- ◊ flexural tensile strength ≥ 4.0 MPa; flexural strength determined on a beam with dimensions of 30 × 30 × 90 cm (for concrete with D_{max} = 100 mm)
- ◊ resistance to water penetration: average depth of water penetration ≤ 5.0 cm, single results of water penetration measurement ≤ 7.0 cm
- ◊ internal resistance of concrete to freezing/thawing: concrete had to be resistant up to 100 cycles of freezing/thawing (M-100), while concrete for the top of the dam had to reach M-150

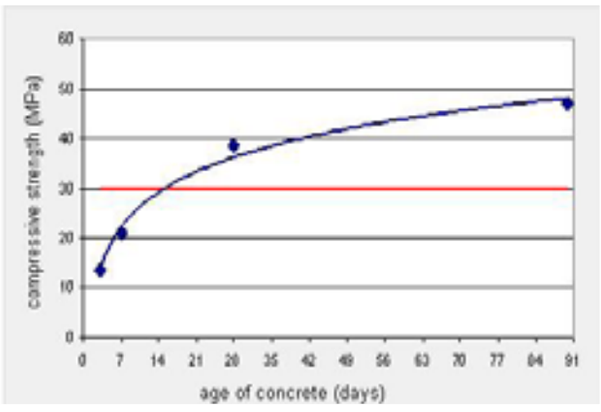

Figure 3: Increase of compressive strength in regard to age of concrete for construction of the dam

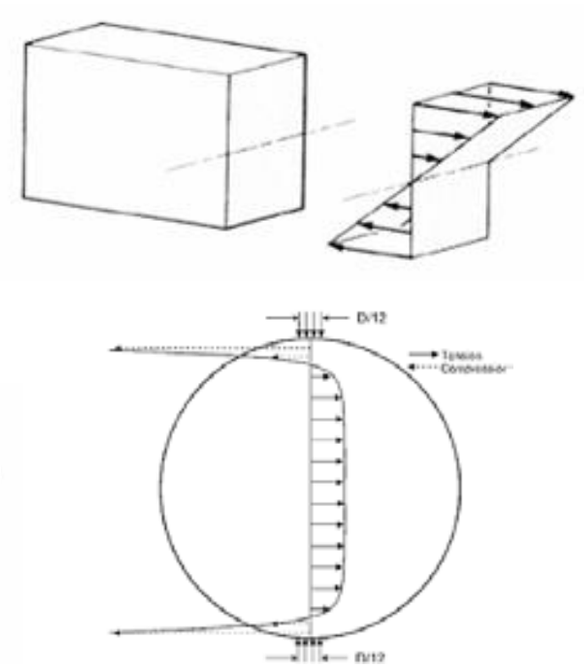

Figure 4: Tensile stresses obtained by the flexural test

Figure 5: Tensile stresses obtained by the split test

3.2 Preparation of the concrete mix proportion

Cement with a denotation of NP 35p 35 (equivalent CEM II/B-P) used in the concrete for the dam construction was prepared in the Titan Cement factory in Skopje. It has 35% natural pozzolan. After 7 days, the heat of hydration of cement in the first batch was 200 J/g and 249 J/g in the second batch. Results of measurements of the adiabatic thermal characteristics (ATC) of the concrete and a study of the thermal behavior of the concrete prepared with cement from the second batch showed that it was suitable for use in the concrete for construction of the dam, although its heat of hydration reached a higher value than that required.

The contractor, Granit AD Skopje, used 270 kg of cement for 1 m^3 of concrete, which met all project requirements. Fine aggregate (0–4 mm) used was river sand, while all other fractions (4–8, 8–16, 16–32, 32–64 and 64–100 mm) were crushed limestone. Naphthalene-lignosulfonate plasticizer was used to improve the workability of the concrete. Segregation of concrete (a large corn fraction of 64–100 mm is taking off from concrete) appeared when containers with a volume less than 1 m^3 were used for transferring the concrete for placement. The consistency of the fresh concrete was in the range of 1.15 to 1.20, measured in accordance with the modified method given by EN 12350-4 Degree of consolidation (measurement carried out in a 30 × 30 × 30 cm mould).

Much higher compressive strengths of concrete with the prescribed water-to-cement ratio were achieved in regard to the required compressive strength (30.0 MPa at 90 days)(Figure 3).

As seen in Figure 3, the compressive strength reached 50 MPa at approximately 90 days. The required class of compressive strength was MB 30 (C25/30) at that age of concrete. Tests of compressive strength were carried out on 30 cm cubes. If those results are calculated for 15 cm cubes (by taking into account factors given in the PBAB), the average compressive strength would be 57 MPa. Because of a much higher compressive strength and cement quantities, it would be reasonable to use concrete with a smaller Dmax than 100 mm, as recommended in some references [2, 3].

Use of concrete with a smaller D_{max} would also be proper on the grounds that modern concrete technology offers many different new solutions and opportunities. Many dams have been constructed in the past with concrete that had a D_{max} of 100 mm and even 200 mm [2], when gravitational mixtures with a horizontal axis were used for concrete preparation. Forced mixtures with rapid mixing are used in modern concrete technology, and the aggregate is dosed from metallic silos to assure uniform moisture. Corn aggregates with a diameter larger than 80 mm would damage modern dosing equipment and the blades of countercurrent mixers. On the other hand, new generations of plasticizers allow the use of concrete with a smaller D_{max} and without a significant increase in the quantity of cement.

The contractor prepared and tested a large number of mix proportions within the framework of the preliminary investigations. Crushed and river sand of 0–4 mm were combined in those proportions. It was found that crushed sand led to a decrease in fresh concrete workability, and therefore only river sand was used in the chosen mix proportion for the preparation of the concrete.

3.2 Flexural tensile strength

Project requirements for the flexural tensile strength of concrete with D_{max} = 100 mm were defined on a 30 × 30 × 90 cm beam. The first difficulty appeared at the time of testing: the mass of one beam was approximately 200 kg, therefore causing major problems in handling the beams.

Furthermore, the test of flexural tensile strength was sensitive to the surface moisture of the specimen. If the surface of a specimen is dry and the concrete still moist inside the beam, tensile strengths will appear in the surface layer acting as fore-loading, which decreases the ultimate flexural strength of the concrete by up to 33% [4].

An additional test has been proposed for the determination of split tensile strength by the "Brazilian method". This method is more robust, and thus the possibility of errors appearing is minor. The resulting tensile strengths are somewhat lower because the loaded surface is larger. This is a "size effect", meaning that tensile strength decreases with an increase in the loaded surface (Figures 4 and 5).

It can be seen in Figures 4 and 5 that only the lower surface of the beam is loaded during the flexural test, while a much larger surface is loaded during the split test, which leads to differences in the results obtained.

Water penetration

Major depths of water penetration under pressure were obtained when concrete with a D_{max} of 100 mm was tested. The surfaces of transition zones of coarse aggregate of 63–100 mm (bound areas between aggregate grains and hardened cement paste) were very large. The average depth of water penetration in the tested samples was extremely low (up to 2 cm), but in the case when large corns of aggregate were present, water under pressure moved along large transition zones up to a depth of 7 to 10 cm. Those transition zones were also not sufficiently filled by cement hydration products and by very fine grains of aggregate. It can be assumed that such an effect would be minor if aggregate with a smaller D_{max} were used in the concrete.

Figure 6: Placement of mass concrete

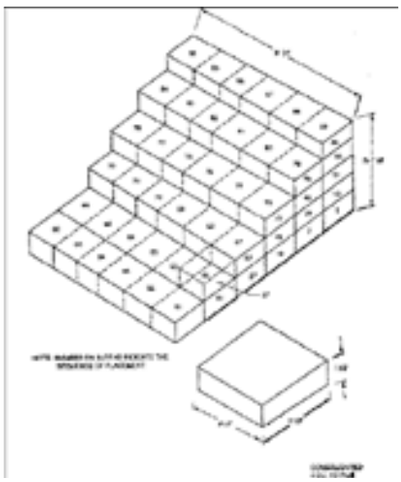

Figure 7: Scheme of mass concrete placement

Figure 8: Installed thermometers in the test block

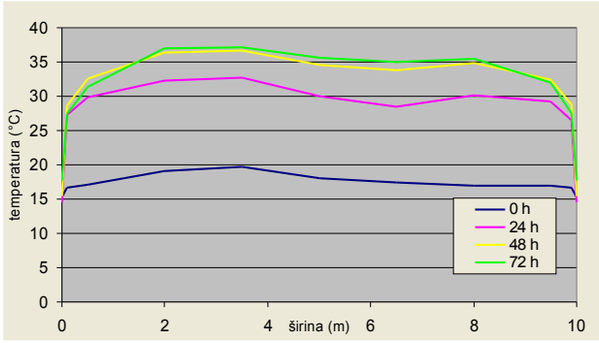

Figure 9: Results of temperature measurements in the test block

Preparation and placement of concrete

Some troubles appeared during the transport of concrete with a D_{max} of 100 mm and with a low level of workability. Local transport of this concrete was carried out in crane containers. Bearing capacity of the crane is very important if the crane has to reach every location where concrete should be placed. Fresh concrete was mixed in the ready-mixed concrete plant and then delivered in a truck mixer with a volume of 9 m^3 to the location where the crane containers were filled.

It was noted that a normal course of construction would take place on the site if the crane could bring concrete in a container with a volume of 2 m^3 (or in a container with a minimum volume of 1 m^3) to a single location for concrete placement. Such equipment assures a capacity of concrete placement of from 20 to 30 m^3/hour. So, concrete blocks of average size could be constructed in approximately 12 hours.

Consolidation of such concrete has to be carried out using high-powered vibrators. Vibrators with a head diameter of 80 mm are suitable for manual vibrating.

A detailed project of transportation and placement of concrete had to be prepared before construction of the first block of concrete, including durations of horizontal and vertical transport and procedures of concrete placement [5]. An example of a scheme of mass concrete placement is given in Figure 7.

Construction of a test block is recommended before starting dam construction. Readiness of the contractor for starting construction, suitability of equipment and knowledge of the workers were thus verified during construction of the test block. First, a test block was constructed on-site, and later, testing of the placement of concrete was carried out (Figure 8).

INVESTIGATIONS

Test block

Before dam construction started, a test block was constructed on-site with a volume approximately the same as the volume of the largest block of the dam. Measurement of the progress of heat of cement hydration in the concrete was

the main goal of constructing the test block [7]. To that end, the temperature of concrete in the block was tracked by 21 thermometers installed in fixed locations in the block (Figure 8, 9).

Samples for investigation of the main required properties of the concrete (compressive strength, flexural tensile strength, resistance to water penetration, internal resistance to freezing and thawing) were prepared during construction of the block. At the same time, the readiness of ready-mixed concrete plants located on the site, readiness of teams for concrete placement, readiness of the laboratory on the site and the suitability of mechanization were established. A report on the findings and results of measurements was prepared after construction of the test block, which represented a base for realization of measures for eliminating errors.

Measurement of heat of hydration with semi-adiabatic methods

Measurement of heat of hydration was carried out using the procedure defined in the paper by P.L. Ng et al. [6]. The adiabatic thermal characteristics of the concrete were measured on-site in semi-adiabatic conditions, where the rise in temperature in the concrete is lower than in adiabatic conditions, because of temperature loss. The difference between the two temperatures depends upon the dimensions of the samples and their isolation.

This method yields an innovative mode of compensation of temperature losses during semi-adiabatic testing, which assures much greater accuracy (± 1.3°C).

In this method, fresh concrete is placed in a wooden box (Figure 11) which is lined inside with thermal insulation with a thickness of 10 cm, so that the interior volume of the box filled with concrete takes the shape of a 50-cm cube (Figure 10). Four thermometers – thermocouples – are inserted into the concrete (in the middle of the cube, in the middle of one lateral face, in the middle of one edge and in the corner of the cube). External temperature (air temperature) is measured with a fifth thermocouple.

Temperature in the concrete cube is measure as long as hydration is still taking place, a minimum of 5 days. A little longer period of measurement is needed when cement with a low heat of hydration is used in the concrete. The decrease in temperature is measured up to the next day after the heat owing to hydration is no longer being generated.

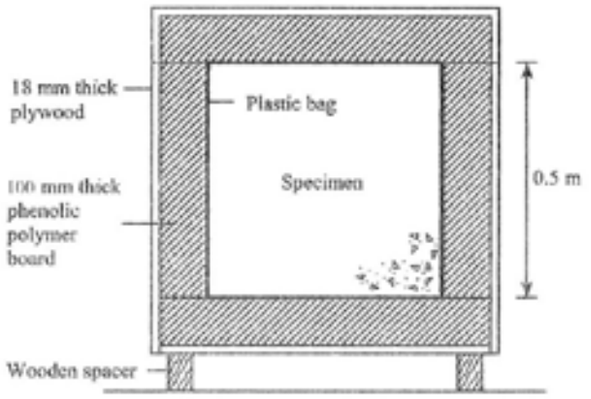

Figure 10: Semi-adiabatic test – schema of the box [6]

Figure 11: Semi-adiabatic test – measurement

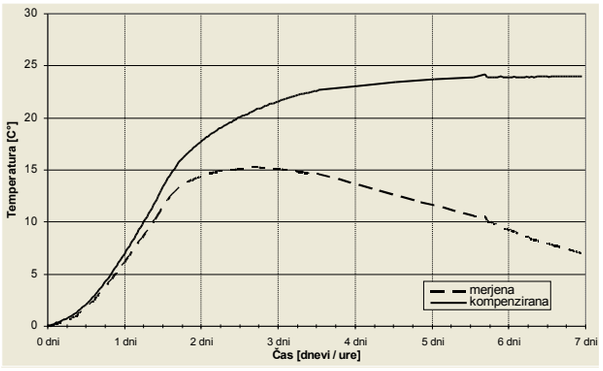

Figure 12: Compensation of temperature losses in semi-adiabatic testing

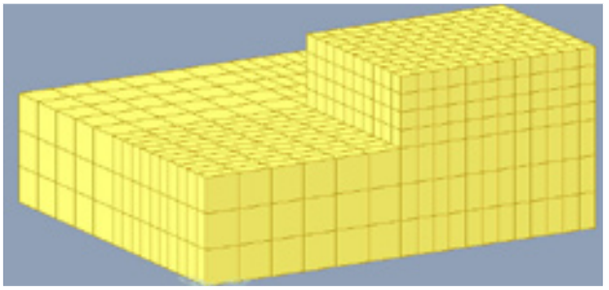

Figure 13: Model of the test block

The coefficient of temperature loss (λ) of the insulated box is calculated on the basis of temperature measured on the last day. This coefficient is used for correction of the obtained temperature of the concrete. The calculation is simple and very easy to carry out in Microsoft Excel (Figure 12).

THERMAL STUDY

Verification of semi-adiabatic methods

Cement with a heat of hydration of 240 J/g, which is higher than the required value (234.3 J/g), was used for concrete placed in the test block. Therefore, a thermal study had to be done to obtain the progress of temperature of the concrete during hydration of the cement and to find out if those temperatures fell within the range of required values.

First, the constructed test block was modeled in midas Civil 2006, v.7.6.1. – trial version. The following data were used:

- ◊ obtained temperatures of concrete placed in the test block and ambient temperature
- ◊ calculated adiabatic temperatures of the concrete as given in item 4.2
- ◊ common material characteristics for grounding and concrete given in the literature (Table 1)

In addition, coefficients of convection on the free surface (50000 J/h_m2_°C) and on the wooden framework (15000 J/h_m^2_°C) were implemented. Air temperature was constant in the model (15°C). The model of the test block in midas Civil is shown in Figure 13. The relation of measured and calculated temperatures is made evident in Figure 14.

The accordance between calculated and measured temperatures was quite good. The calculated temperature was 1°C lower on average in regard to measured temperature. This difference was due to errors in measurement of heat relaxation in the semi-adiabatic conditions (inaccurate placement of thermocouples, one surface of insulation was not covered with a wooden board, a slightly higher quantity of concrete was placed in the box). Therefore, heat loss was higher through one

Table 1: Adopted material characteristics

material	k [J/m_h_°C]	specific heat c [J/kg_°C]	[kg/m3]	initial temperature [°C]
concrete	9000	950	2400	16
grounding	6000	800	2400	10

of the faces, and for that reason the calculated temperatures were somewhat lower.

Much better agreement of the highest temperatures reached (difference < 0.5°C) was obtained by repeated measurement of heat relaxation in accordance with the semi-adiabatic method.

Prediction of temperatures in the block during cement hydration
In the second step, construction of the block under the most extreme conditions allowed by the project was assumed. Air temperature was 30°C, and the initial temperature of the concrete and temperature of the grounding was 20°C. Temperatures of the concrete in the middle of the block, 50 cm below the surface and on the bottom of the block are shown in Figure 15.

Temperatures in the center of the block were slightly above 40°C. Furthermore, a calculation error (+1°C) had to be added, so the temperature in the block came to approximately 42°C. This temperature was somewhat higher than required, and therefore it would be proper to examine closely whether such tensile strength can appear due to the temperature of the concrete, which will cause cracks on the surface of the concrete block.

Tensile strength on account of temperatures in hardening concrete in the block

Cracks in concrete appear due to an excessive difference between maximum temperature and ultimate temperature of the concrete. Such cracks appear during the gradual cooling of the concrete block. The calculation of tensile strength due to cooling of the concrete block is given in ACI 207.2. The appearance of cracks due to cooling of the mass concrete block is shown in Figure 16.

Cracks can also appear due to too great a difference between the temperature in the center of the concrete block and that of the surface of the block. These

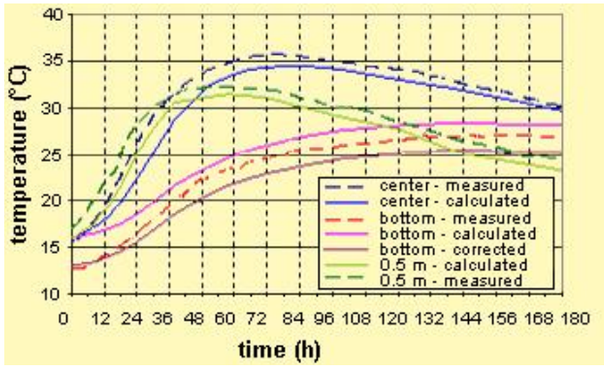

Figure 14: Measured and calculated temperature

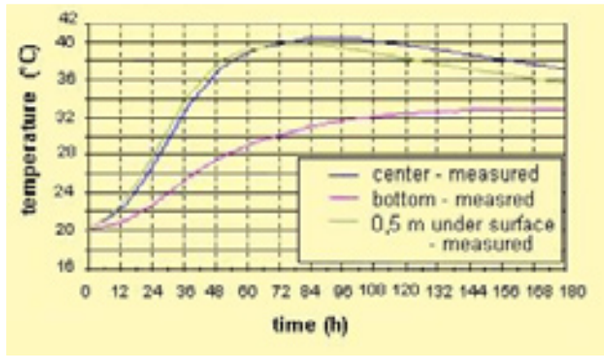

Figure 15: Temperatures in the concrete block under extreme conditions

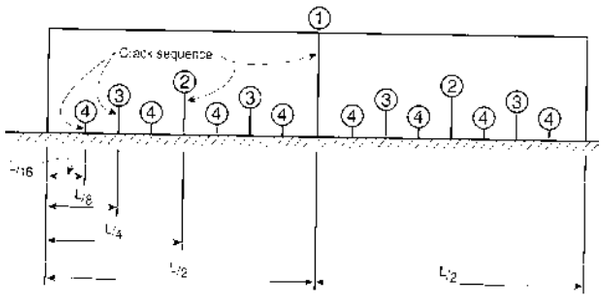

Figure 16: Appearance of cracks during cooling of the mass concrete block [8]

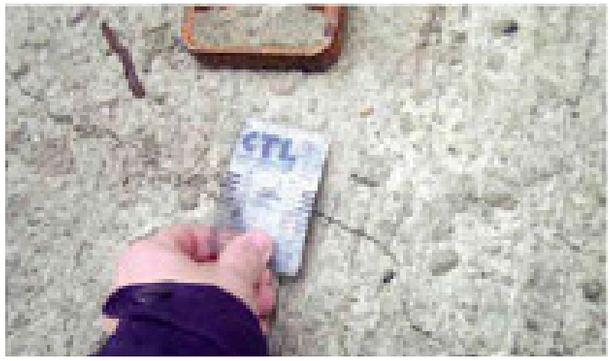

Figure 17: Cracking due to temperature differences in mass concrete [8]

cracks are usually shallower, appearing when concrete in the middle of a block reaches the maximum temperature, or when the formwork is removed during disadvantageous weather conditions (cold weather). Such cracks would be dangerous if they appeared on the upward side of the dam. In this case, water could penetrate into these cracks, and due to high water pressure, the cracks could propagate and open. Such cracking is shown in Figure 17.

CONCLUSION

Construction of hydraulic structures is complex work requiring a high level of knowledge in the area of concrete technology. Construction technology differs from site to site and is also dependent on the equipment available to the contractor. There can also be discrepancies between the desires of the investor, requirements of the designer and capabilities of the contractor. Reaching a suitable solution is frequently exhausting, but with the help of new materials, technologies of preparation, transportation and the placing of concrete these solutions can be arrived at much more easily.

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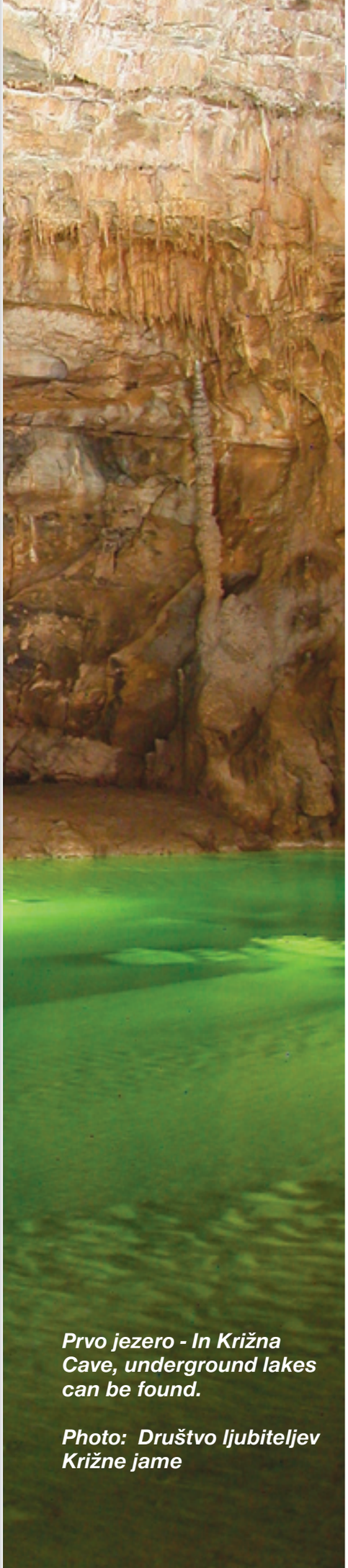
Green Karst – EnVision the Future

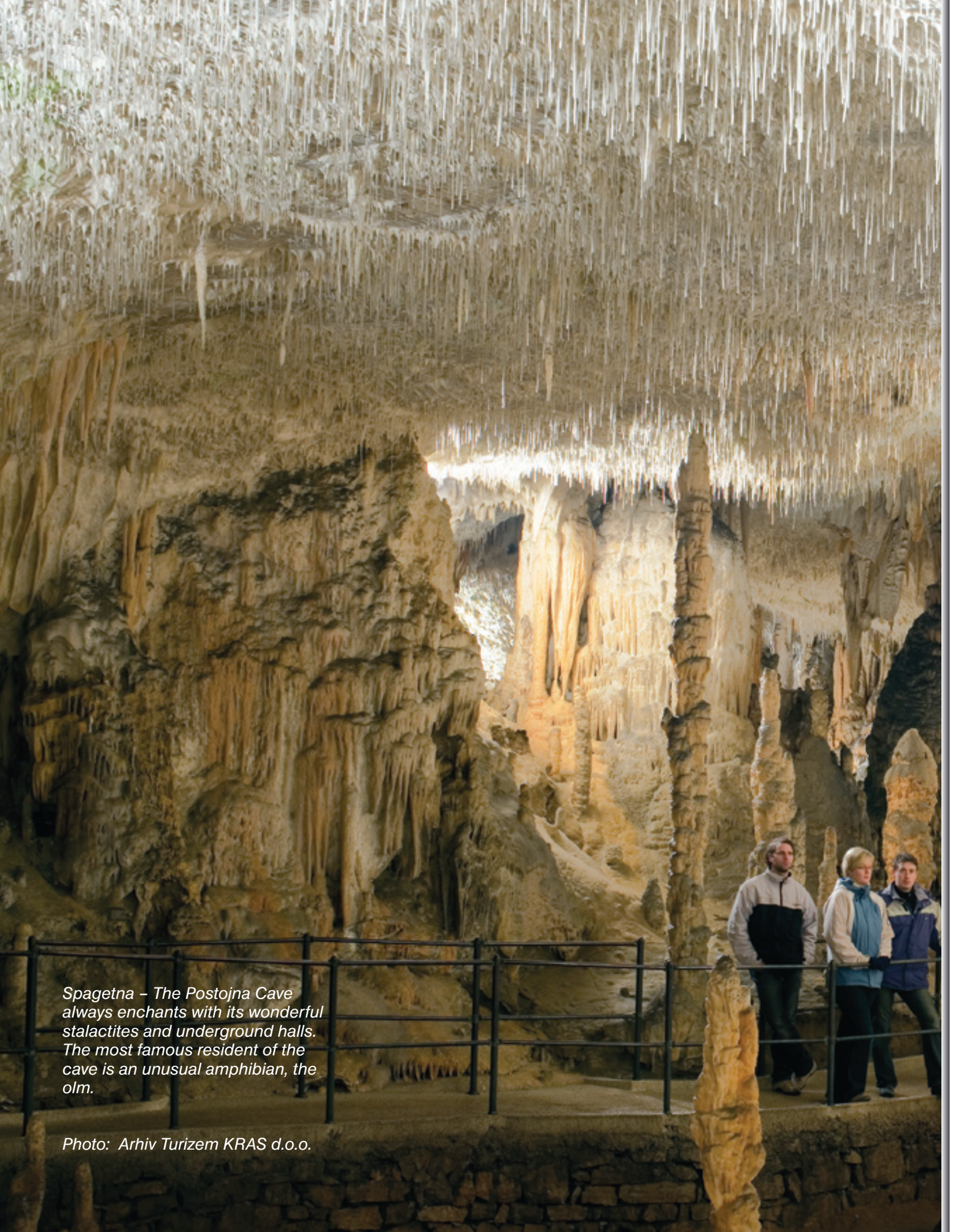
Lucija Marovt

The Slovenian municipalities of Bloke, Cerknica, Ilirska Bistrica, Logatec, Loška dolina, Pivka and Postojna decided to create a new vision of development for the Notranjska-Karst region. As the region is well known for its unique and well-preserved natural and cultural heritage, the common future vision of the region is based on sustainable development and the cohabitation of nature and people. In the process of identification of the new vision of the Notranjska-Karst region, a new brand and graphical image for promotional purposes was developed – the Green Karst. The aim of the newly identified regional vision is to raise the recognition of the Green Karst brand through the active participation of different organisations and individuals inside the region, as well as beyond its borders.



Prvo jezero - In Križna Cave, underground lakes can be found.

Photo: Društvo ljubiteljev Križne jame



Spagetna – The Postojna Cave always enchants with its wonderful stalactites and underground halls. The most famous resident of the cave is an unusual amphibian, the olm.

Photo: Arhiv Turizem KRAS d.o.o.

Regional characteristics as a basis for a sustainable vision

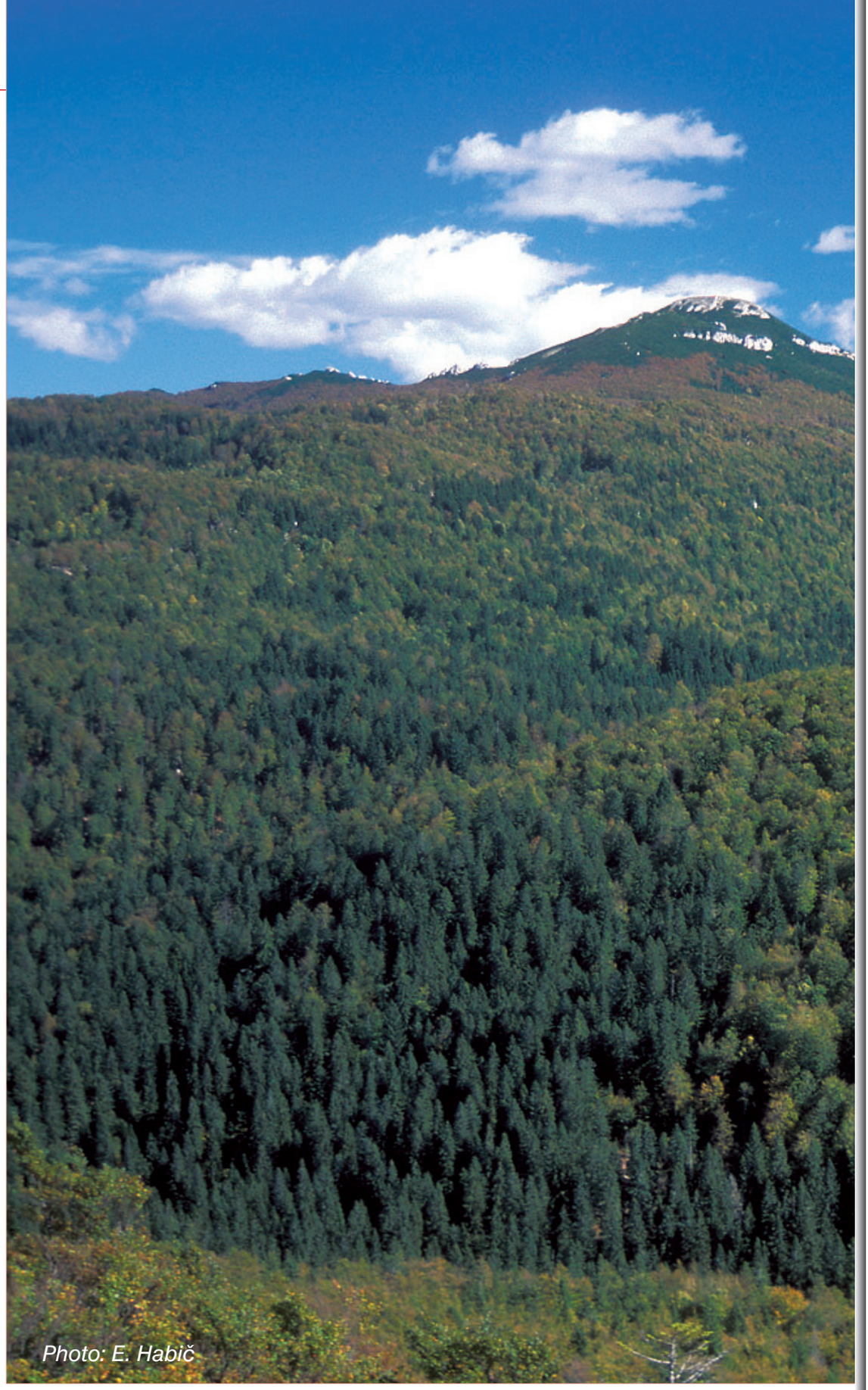
The Green Karst region is one of the most sparsely inhabited areas in Slovenia: there are 51,000 people living on 1,456 km^2 which means only 35 people living per km^2. Intact and unspoiled natural features offer shelter to numerous endangered species and this is the reason why 54% of this area is included in the Natura 2000 network. The region is very famous for its numerous karstic features: Cerknica Lake, the largest disappearing lake in Slovenia, Planina Polje, a world-famous example of karstic plain, caves (Postojna Cave, Križna Cave), and its cultural heritage: Predjama Castle, Snežnik Castle, Prem Castle and many others. The area also offers extensive typical forests.

Well-preserved natural and cultural heritage represent a unique opportunity to develop the economy, as well as agriculture, on the principles of sustainable development, to stimulate the use of renewable energy sources, and to encourage tourism that will respect and preserve nature.

Development of the Green Karst brand

One of the most important steps in the process of developing a new strategy and vision for the region was identification of the key features that represent what the region is and what its advantages are in comparison with other regions. The systematic process also included definition of a new name in which representatives of organisations as well as individuals from various fields of interest actively co-operated.

After the reconciliation of different proposals, the most suitable name for the new concept of the region was recognised: "Green Karst". The expression "green" illustrates one part of the region – its vast forests as well as the environmentally friendly course of the development of the region. The word "karst" illustrates the other part of the region, famous for its natural phenomena that are known around the world and which represent great developmental potential. The name "Green Karst" therefore directly emphasises the key characteristics of this region – a green karstic world that is unique in Slovenia.



Snežnik (1796 m) is the highest mountain in the Green Karst area.

On the basis of the brand and name Green Karst a logo and brand headline were developed:

The Goals of the Green Karst

The Green Karst region is gaining a new development impulse that will

increase its recognition and reputation and motivate organisations and individuals for cooperation inside and outside the region. For this reason, the region has set ambitious, but feasible goals:

◊ The Green Karst will preserve nature and a healthy living environment that represents the basis for the development of the region. With stimulation for reaching higher standards in the field of environmental protection, and with increased environmental awareness, the Green Karst will protect the potentials of nature.

◊ The region will take care of the evolution of development and research institutions that will help to create and form new products and services. These institutions will,

Park 065 – The Green Karst region provides shelter to many bird species. One of the internationally known bird-watching areas is Lake Cerknica, where over 250 bird species can be found.

besides expansion of the market for their products, also create developmental potential and new working places.

◊ Integrated tourist products and services will change tourist demand. The Green Karst will assure the development of tourist infrastructure and products on the local level and connect these into integrated regional products that will also include the service sector and agriculture.

The Green Karst region is one of the most sparsely inhabited areas in Slovenia: there are 51,000 people living on 1,456 km2 i.e. 35 people per km2.

Four directions to reach regional goals

The Green Karst is the first region in Slovenia aiming to stimulate the development of the whole region in accordance with the principles of sustainable development and on the basis of tradition. To successfully realise the strategy of the Green Karst, four foundations of development were defined.

Tourism is one of the most relevant development directions in the region. The Green Karst's natural and cultural jewels include Cerknica Lake, Planina Polje, Postojna cave, Križna cave, Predjama Castle, Snežnik Castle, Prem Castle, the Pivka Park of Military History and others that offer endless possibilities for active holidays, including numerous bike trails, hiking, horseback riding, exploring caves, etc. The latest trends for the region show an increase of investments in the tourist infrastructure. The aim of the new strategy is also to increase lodging capacities throughout the region and to offer tourists opportunities and ideas on how to spend their time in the Green Karst.

Grad Snežnik – Snežnik Castle is the best preserved castle in the region.

The second important direction is agriculture with supplementary activities on farms. Two so-called local action groups in the region are planning and proposing different projects to bring the Green Karst brand into life to encourage investments and co-operation among different organisations and individuals from inside and outside the Green Karst. The region is currently developing common implementation and promotion of the most typical and famous regional products that will be presented within the Green Karst brand. Categories of regional products include: cheese (from goats, cows, and sheep), cottage cheese, strong drinks (gin, plum brandy, fruit brandy and fruit liqueur), honey, fruit products (fruit bread, vinegar), fresh vegetables and products from herbs. These activities will help to preserve and increase the quality of life in the countryside and to spread traditional activities.

The Green Karst region has low level of unemployment but is also confronted with very low added value. Therefore, the economy is the third direction that will contribute to higher value added, per unit of product and per employee. For this reason, the region will stimulate the development of small and medium companies especially in the field of product development and in the service sector. A specific increase in the innovative potential of companies in the field of environmental friendly technologies would also be beneficial, and more financial initiatives should be encouraged to this end.

Last, but not least, knowledge is the common attribute for all development directions as the implementation of the Green Karst vision depends on human resources. Specialised knowledge is the key to creating new, contemporary products and services that will bring recognition to the region, along with people with higher education and new working places with higher value added.

The key directions for regional development undoubtedly bring many opportunities for new investments for business and for organisations from the public and private sector, as well as individuals – not only those living and working in this region but also those from neighbouring regions. Natural and cultural beauty is therefore only one side of the region. The other part is the real intention to live and share a new vision with all who visit the Green Karst.

Štirna na Kalu – One of the greatest stone cutting achievements is an old reservoir dating from the second half of the 19th century.

The Story of Those Who Wear Nothing but Feathers

Davorin Tome

The most obvious feature distinguishing a bird from the other tens of millions species dwelling on our planet is not its ability to fly, which is perhaps what first crossed your mind. Several other creatures have adapted to travel through the air, using wings. Many insects for example, also some mammals and (extinct) reptiles. The feature that makes an animal unmistakably a bird is the feather, a unique product of evolution found only in the birds. Although very simple in construction, it is a very powerful invention, that serves birds for several purposes. It protects them from burning desert sun, daily tropical showers and freezing Antarctic winds; it gives them a recognisable shape; coloured in red or yellow it gives them a fearsome appearance, coloured brown it hides them from the eyes of predators; and of course, the feather gives birds the possibility of flight. And for majority of the almost 10,000 bird species on Earth, flying is their way of life.

Davorin Tome, National institute of biology

There are few birds in the world that cannot be differentiated by the colour of their feathers. The European bee-eater (Merops apiaster) is one of the most colourful birds in Slovenia.

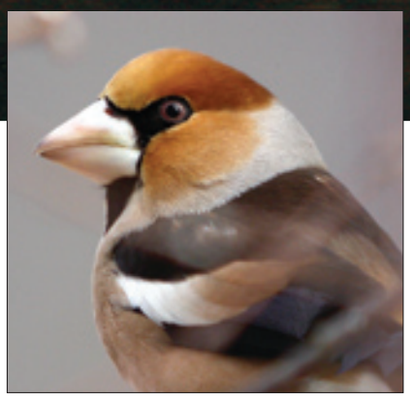
Flying opens to birds the unique possibility of long-distance travel. In truth, some species of birds (we called them residents), such as sparrows, do not travel far. They spend their life in one country, even in one town or one street. But some birds spend half of the year in one location and the other half in a totally different, often very distant, location, even on another continent. Since birds travel such long distances in an orderly manner (all at the same time and in the same direction), we have a special word for this type of travelling – migration. Starlings and Barn swallows are two such migratory birds. But it is fair to say that they are far from alone. About half of the European birds migrate, and all share a similar migration schedule. They breed in Europe during the spring and summer and in autumn they migrate to the south. Some migrate to the Mediterranean, but majority to Africa, where they spend the winter. When the winter ends, they return to their place of birth in Europe. There is not a single bird that does the opposite of this i.e. breeds in Africa and winters in Europe.

A feather – a unique product of evolution found only in birds. End part of the peacock (Pavo cristatus) tail feather.

Although all birds have feathers, they can be very different from each other - a consequence of adaptation to different living conditions. They are different in size, for example: from hummingbirds weighing less than three grams to albatrosses with a wing span of three metres and more. Birds also differ tremendously in the size and shape of their beaks. A bird's beak is a good indicator of its feeding habits. Birds feeding on fish, such as herons, have a long, sharp, spear-like bill. Granivorous birds (which feed on seeds) have a short and

Photo: Davorin Tome

The distribution of the black-headed bunting (Emberiza melanocephala) in Slovenia is limited to the Primorska region.



The size and shape of the beak tells us about the feeding habits of the bird. Seed-eating birds usually have strong and short beaks, like the hawfinch (Coccotraustes coccotraustes). Raptors, like this golden eagle (Aquila chrysaetos) have a hook-shaped beak.

very massive bill. One of the most powerful is that of the hawfinch. The bills of predators, such as eagles, hawks or owls, are hooked. They use their bills to tear the skin and flesh of their prey. Birds feeding on small insects have a short, narrow bill, resembling very delicate tweezers. Some waders search for their food in the mud. Their bill is slender and fairly long, so that they can stab deep into the soft ground. In some species it can be almost as long as the bird itself.

All birds reproduce with eggs. There is not a single bird species that gives birth to already-developed offspring. Eggs are laid in nests and incubated with body temperature for about two weeks in smaller birds and up to two months in larger birds. Young birds usually depend on the parents for several weeks after hatching, even up to a year in some slow-developing species.

Birds build nests to help them protect eggs against severe weather conditions and against predators. The shape and position of the nest is often so unique that only the trained eye can tell which species built it, even if the owner is long gone. The biggest nests, those of storks or some eagles, are made from twigs and are so vast, that they can weigh several tonnes. Even the oldest trees in a forest may fall under the weight of such a nest. Some birds, on the other hand, have very minimal nests. The little ringed plover, which lives on gravel beds beside rivers, only scratches a shallow depression on the ground as a nest. The most common design is a nest constructed on a tree branch, but some species also hang a nest under the branch. Others hide the nest in a tree trunk, deep under

Photo: Davorin Tome

the ground, or among tall grass. Water birds can build floating nests in the middle of lakes, far from the reach of land predators, while dippers place it behind a waterfall. The only access to this nest is through running water.
Construction of the nest, incubating the eggs and taking care for the offspring is very demanding in time and energy terms, so some species have found a way around this. Cuckoos do not build a nest and do not incubate their eggs. They lay eggs in the nest of other birds and let them take care of their young. Since cuckoos are not extinct, this strategy can be considered successful.

Birds in Slovenia

In spite of Slovenia's small size, its unique geographic position makes it a very diverse country. Within the borders are parts of the Alps, the Dinarids, and sections of the Pannonian and Mediterranean regions. This diversity is well reflected in diversity of birds. A little over 200 species breed in Slovenia regularly. Considering also birds that winter in Slovenia, or only fly across during the spring or autumn migration, almost 400 species have been seen. The Alpine chough, for example, is a typical bird living only in the Alpine region. Without the Pannonian flats, Slovenia would have almost no white storks. The vast majority of about 200 active stork nests in Slovenia are located in Štajerska and Prekmurje. Several bird species breed only in Mediterranean region, such as Cetti's warbler, the fantail warbler, and the black-headed bunting. Compared with other European countries, Slovenia is very heavily forested, so forest-bird populations are particularly large. One of the most eminent forest birds

Not all birds are colourful. Some have feathers with more uniform colours. But this does not mean that they are not worth looking at. On the contrary, the combination of brown and black colours can be breathtaking, too. A tree sparrow (Passer montanus).

is the Ural owl. It is big, it is powerful, it is fearless, and there are still many in Slovenia, although they are difficult to spot.

The mystery of bird migration

Much of the migration is an unseen passage. In spring, the woods and grass-

Birds can fly, but this is not their most characteristic feature. Several other animal groups can fly too. Black-headed gull (Larus ridibundus) in winter plumage.

There are still many mysteries about bird migration. How do they make it, how do they find their way, how do they manage to return to the same nest year after year, etc? Common cranes (Grus grus) on a migration flight.

The barn swallow (Hirundo rustica) is among the best-known migratory birds. Its breeding range is in Europe, but before the winter it migrates to South Africa.

lands of the Northern Hemisphere are suddenly full of singing birds. Hordes of birds creep in unnoticed. Just as they appeared, they disappear again in the autumn. People were always puzzled where the birds went in winter. The mystery began to be revealed just a century ago, when scientists started systematic work on capturing and recapturing birds.

For a long period, the only information on bird migration was gained through ringing data. The birds were trapped on their breeding grounds in Europe, metal rings with a unique engraved code were fitted to their legs and they were then released. With luck, some ringed birds would be trapped again on wintering grounds. The recapture rate of ringed birds is typically very low. For recapture of a single bird with a metal ring on wintering grounds, tens of thousands must usually be ringed on breeding grounds. And for a decent picture of the migration route of a particular species, a single recapture is not nearly enough. For some species, even 1,000 recaptures is just a small contribution to the knowledge.

Ringing is the oldest method for study of bird migration. A metal ring with a unique engraved code is fitted to the bird's leg (the bottom ring on the left leg). Whenever and wherever the bird is recaptured, the ring tells a researcher exactly from where it originated. For easier recognition of individual birds over a short distance, plastic rings of different colours can also be used.

Recently, a much more efficient method for studying migration in birds has become available – satellite telemetry. A GPS satellite transmitter is attached to a bird as a backpack, constantly emitting the geographical co-ordinates of the bird. The satellite in orbit intercepts the signal from the transmitter and passes the information to researchers in laboratories. Now, for 1,000 very detailed migration routes, only 1,000 birds need be captured and tracked. The downside of the method is that the transmitters are heavy. The lightest weigh about 20 g, so only big birds, such as raptors or geese, can be tracked in this way. But it is only a matter of time before scientists will be able to equip even small birds with transmitters. The first transmitter used for tracking animal migration was manufactured in 1970 and weighed about 10 kg. It was used on a moose, since no bird could carry such a load. With the current speed of technological development, it will probably take less than another 40 years before transmitters will be small enough to put on a bird of the size of a sparrow.

Birds as indicators of environmental changes

Birds are excellent indicators of changes in environment. This makes them good bioindicators. They are at the top of food webs (almost all are predators, at least for part of the year feeding on other animals), which makes them sensitive to changes on almost every level in ecosystems. Different species make use of resources from different ecosystems, so birds can be used as indicators of changes in forests, agricultural land, wetlands, etc. Since birds can fly, they alert us to changes very quickly. They fly away as soon as conditions deteriorate. People also enjoy watching birds, so there is usually someone in the field who notices that a bird is gone.

Ornithology in the National Institute of Biology

At the National Institute of Biology, we have studied birds for 20 years. The group of ornithologists at the institute is young and small for now. We have two main basic research topics: interactions between owl species in the forest and interactions between humans and birds in agricultural land, especially grassland birds.

All birds are particularly vulnerable during the breeding period, when they are caring for their offspring in the nest. No matter what the type of threat at this time, the nest cannot be moved to a safer position. All birds can do is to save themselves by abandoning the nest. But this comes at a high price – the death of the offspring. And without yearly production of offspring, extinction is just around the corner.

The breeding period of grassland birds today coincides strongly with the

The grasshopper warbler (Locustella naevia) is a typical grassland bird. It breeds and lives its whole life on grasslands.

Photo: Davorin Tome

Interaction among forest owls is one of the two main research topics of the ornithology group at the National Institute of Biology. All breeding data on owls is collected from nest boxes. For this purpose, the group has a network of nest boxes across the forests on Mt Krim, which are visited regularly.

In Slovenia, the Alpine chough (Pyrrhoccorax graculus) is found only within the Alpine region.

mowing date. It is probably not necessary to say that this coincidence can destroy all nests in a grassland. And since it happens year after year, many grassland birds have already suffered heavy losses. To find a solution to this problem it is important to first have a good understanding of grassland bird ecology, and secondly, to meet farmers' needs too. Without birds, we face a collapse of the grassland ecosystem as we know it. Without farmers and mowing, on the other hand, forests would spread over the grassland, again causing a collapse of the ecosystem. So the solution is somewhere in the delicate balance between nature and human activity. We just have to find it.

Birds are threatened

Many birds in Slovenia are threatened, some even with extinction. More than 50% of species are listed on the IUCN Red List. The main causes of threat are urbanisation, improved agricultural practice, unsustainable forestry, drainage of wetlands, and alterations and regulation of rivers. All threats are directly caused by humans. We claim more and more space and energy for us, leaving birds and other wildlife to lead a miserable existence on leftovers. Several bird-protection schemes are currently in place, and other new schemes are proposed. IBA (Important bird areas), SPA (special protected areas) and Natura 2000 are three bird-conservation schemes with broad international support, which are in operation in Slovenia. In spite of these efforts, bird populations all over Europe are still decreasing – forest birds by 9% and farmland species by 48% in the past 25 years. But there are at least some signs that the speed of the population decline is decreasing. In a decade or so, the reduction of many bird populations should be stopped, as long as the consequences of global warming, another potential threat to birds, is not too severe.

Use of Rapid-prototyping Technology in Rehabilitation of a Patient with Facial Deformity or Partial finger or Hand Amputation

T. Maver, H. Burger, N. Ihan Hren, L. Botolin, J. Weingartner and K. Celec,

Abstract: We have been manufacturing and applying epitheses at the University Rehabilitation Institute of the Republic of Slovenia since 1993. Epitheses are aesthetic prostheses replacing individual body parts. Our experience demonstrates that patients wish to replace the lost part of their body with a prosthesis – an epithesis that is a mirror image of the relevant healthy part of the body. Six years ago, we linked up with other institutions, companies and the University of Ljubljana to search for new, more advanced technological possibilities to bring the form of epitheses closer to the form of a healthy hand or part of a face. Healthy and impaired parts of the body were scanned. A digital virtual model was made using a computer program. 3D-printing technology, DMLS (Direct Metal Laser Sintering) and SLS (Select Laser Sintering) technology were used to build up a first model or mould for manufacturing a silicone epithesis. Through this development project, we have developed high-resolution digitising of body parts and technology to produce a prototype model and mould allowing fine recognition of skin details. The time required for design and manufacture is now shorter. By using CAD-CAM high-resolution technology, the highest-quality prosthetic design can be achieved, even when the prosthetist lacks artistic skills.

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The University Rehabilitation Institute, Republic of Slovenia

Robert Cugelj

The University Rehabilitation Institute, Republic of Slovenia is the main national health institution offering comprehensive rehabilitation services to people with disabilities in motor functions and of work abilities. The institute carries out rehabilitation programmes and is responsible for the balanced development of all health and other professional branches related to the issue of rehabilitation at the national level. The Institute treats around 15,000 patients a year, including over 1,900 treated in hospital wards with a total capacity of 200 beds. Operating within the institute are several specialised and subspecialised clinics for screening, rehabilitation diagnostics and therapy of patients with severe impairments and disorders of the locomotor system and resulting disabilities. Approximately 90% of the patients come from the Republic of Slovenia and the remainder from abroad. The expert staff of the institute has included excellent teachers in medical, technical and social fields throughout the 50 years of its development.

From the perspective of organisation, the activities of the institute can be grouped as follows:

- ◊ Clinical hospital for physical medicine and rehabilitation;
- ◊ Centre for vocational rehabilitation;
- ◊ Centre for prosthetics and orthotics;
- ◊ Outpatient rehabilitation services;
- ◊ Rehabilitation engineering;
- ◊ Pharmacy.

The healthcare activities are aimed at providing inpatient and outpatient care for the patients of the institute. Modern patient care at the institute tends towards outpatient diagnostics. The therapeutic services of the institute are working towards shorter hospitalisation and outpatient treatment.

The institute as a healthcare institution at the tertiary level carries out scientific research in the fields of medicine, rehabilitation engineering, as well as in the psychosocial field and in the field of employment. It has about 50 employees who are registered as researchers or associate researchers at the Slovenian Research Agency. Scientific research is carried out within individual organisational units and within the research department, which offers professional, technical and logistical help to other departments in the preparation and implementation of research and dissemination of its results.

I. INTRODUCTION

We have been manufacturing and applying epitheses at the University Rehabilitation Institute Republic of Slovenia since 1993, using silicone technology (Figure 1,2). Currently, this technology is based on manual shaping, through which we strive to restore the patient's aesthetic appearance (Figure 3,4).

Figure1

Figure 2

Our experience demonstrates that patients wish to replace the lost part of their body with a prosthesis that is a mirror image of the relevant healthy part of the body.

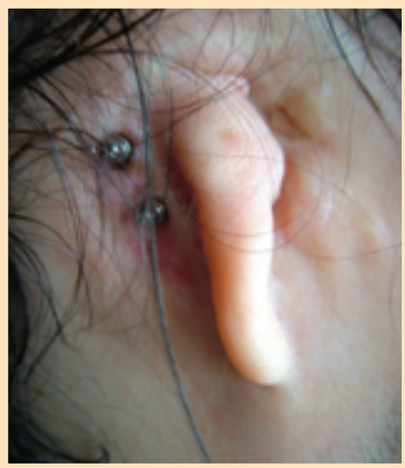


Figure 3

Figure 4

Four years ago, we linked up with other institutions and the University of Ljubljana to search for new, more advanced technological possibilities to bring the form of epitheses closer to the form of a healthy hand or part of a face.

To this end, we started development of an appropriate high-resolution CAD-CAM system.

Figure 6

II. TECHNOLOGY

The development project covers three areas:

- ◊ a scanning system;
- ◊ positive model-construction technology; and
- ◊ tool-construction technology.

Scanning system

During the development phase, three laser and optical scanners were tested in the making of a digital-3D model of a hand and stump. The following scanners were tested: freescanner CAPOD CAD-CAM system, Zscanner 700 (Figure 5) and 3D-optical scanner ATOS II 400 (Figure 6).

First, a plaster model of the healthy part of the body was scanned (Figure 7).

Figure 5

Later, a plaster model of the impaired part of the body that had previously been corrected was scanned (Figure 8).

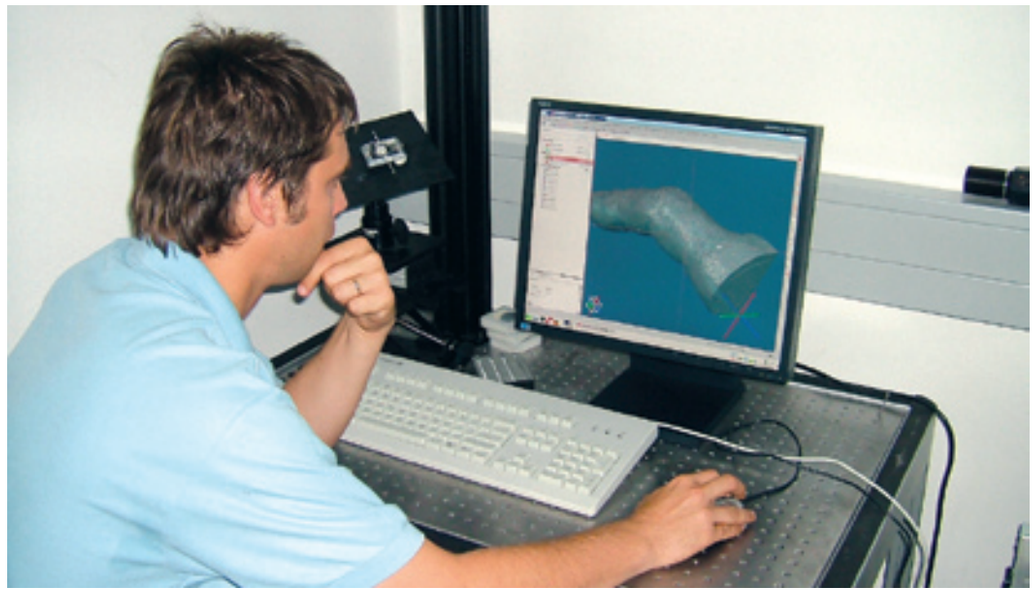
Weingartner, RTCZ Rapid Prototyping and Rapid Tooling Centre, Hrastnik, Slovenia

Helena Burger, University Rehabilitation Institute Republic of Slovenia, Centre for Orthotics and Prosthetics, Ljubljana, Slovenia

Kristjan Celec, IB-PROCADD d.o.o., Dunajska 106, Ljubljana, Slovenia

Positive model-construction technology

Figure 10



A digital virtual model was made using a computer program (Figure 9).

Figure 11

The healthy part of the body was treated and a mirror image of the digital model was thereby obtained (Figure 10,11,12).

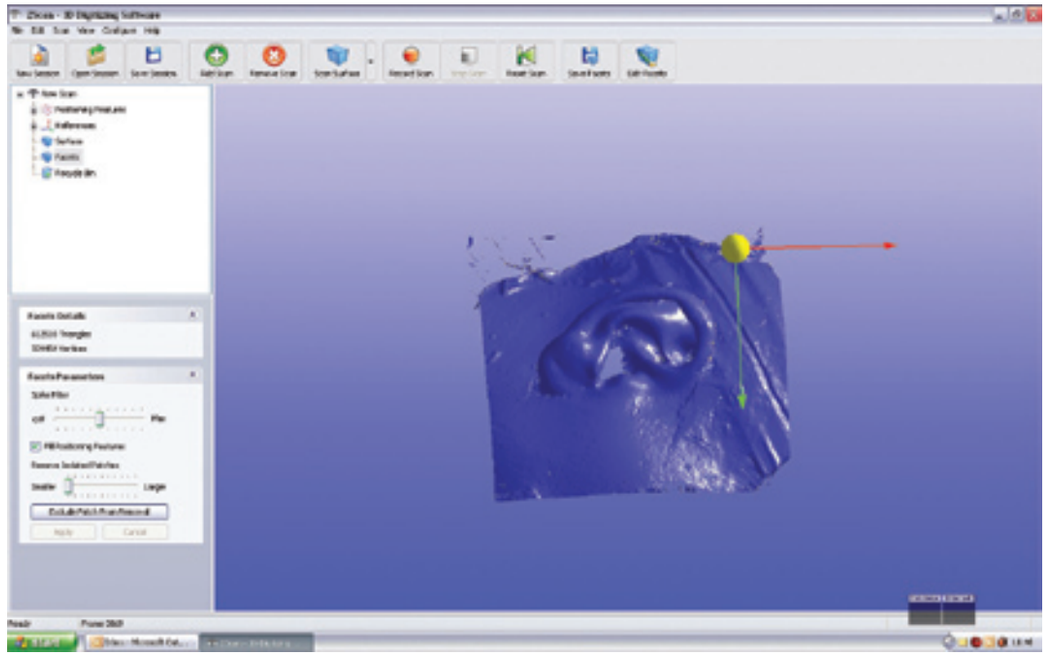


Figure 12

Figure 13

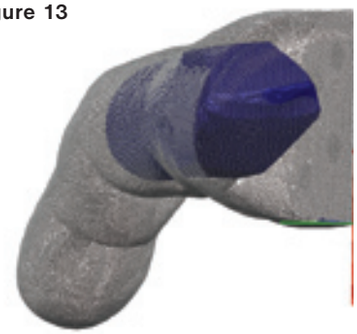


Figure 14

Figure 15

This virtual digital model was then gradually adjusted to the model of the impaired part of the body (Figure 13,14,15). The digital picture of the model was transferred to the STL database.

Mould-construction technology

3D-printing technology, SLS (Select Laser Sintering) and DMLS (Direct Metal Laser Sintering) technology were used to build up a first model or mould.

Figure 16

3D-printing technology was used to make a prototype model of the auricular and finger epithesis (Figure 16, 17).

Figure 16

Figure 18

DMLS technology was used to make a tool for manufacturing a silicone finger epithesis (Figure 18).

At the final trial, SLS technology was used to produce a tool for manufacturing a silicone finger epithesis (Figure 19).

Figure 19

III. RESULTS

With the assistance of experts from the companies participating in this project, we tested and identified the devices and technological procedures to enable the manufacture of epitheses.

The best results in scanning were achieved using the ATOS II photo scanner (Figure 20). When scanning directly on the body, there were some problems due to slight movements of the body. This was the reason for additionally scanning plaster models of the healthy as well as the impaired parts of the body.

Figure 20

The virtual positive model shows all skin details, including fingerprints (Figure 11). In this way, the first part of the development project was completed.

This virtual model helps to make a prototype model of an epithesis or mould in the STL database. The program allows adaptation of the digital model of the healthy part of the body to the digital model of the stump (Figure 14) or the impaired part of the face.

The highest apparency of skin details in the mould was achieved using the DMLS technology (Direct Metal Laser Sintering) with 0.04mm accuracy. In the testing of the SLS (Select Laser Sintering) technology and the print technology, the accuracy was 0.1mm. When inspecting the moulds, the most accurate surface was found to be that produced by the DMLS technology. Silicone was poured into the moulds and, after vulcanisation, the quality of the test prostheses was found to depend on the apparency of the skin prints. The highest quality for the mould surface was achieved by the DMLS technology and the lowest by the 3D-print technology, which produced a rougher surface for the prostheses test model, despite the satisfactory apparency of the skin prints. The SLS technology was selected for mould manufacturing due to its accessible cost. The apparency of skin prints achieved by the SLS was not essentially lower than that achieved by the DMLS technology.

The mould can be directly used to be filled with silicone material (Figure 21).

Figure 21

IV. CONCLUSIONS

During the development phase, CAD-CAM technology processes were defined to enable production of silicone prostheses after partial hand amputation (Figure 22, 22a), which in their form mirror the patient's healthy hand (Figure 23).

Figure 22

Figure 22a

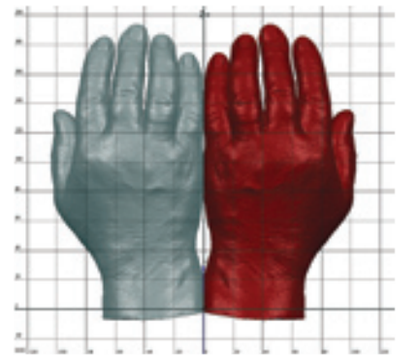


Figure 23

Most centres for manufacturing silicone hand prostheses currently use manual modelling. The quality of such prostheses depends largely on the artistic skills of the prosthetist. By using CAD-CAM high-resolution technology, the highest-quality prosthetic design can be achieved even when the prosthetist lacks artistic skills. Rapid-prototyping technology has been already used in designing and making of maxillofacial prostheses – epitheses (Figure 24, 25), as has already been treated in international expert literature.

The final appearance of the prosthesis depends greatly on its shape and colour (Figure 26, 27). Our experience in using the CAD-CAM high-resolution technology have shown that this technology enables computer-based manufacturing of prostheses, which in their form mirror the healthy hand.

Figure 24

Figure 25

Figure 26

Figure 27

The use of such technology reduces the time required for design and manufacture. However, the technological process is more expensive due to the application of highly developed technology, which means the product – the epithesis – is also more costly. We are working on reducing the number of steps in the technological process to improve speed, accuracy and cost, so our patients can be offered optimal quality at affordable prices.

Facing the knowledge challenges of 21st-century society with an outdated education system can only be done with an integrated approach blending technology, the best teaching techniques and top educators.

Real Learning

Laboratory for Telecommunications, Faculty of Electrical Engineering, University of Ljubljana

Andrej Gregorc

A 19th century school system for the challenges of the 21st-century knowledge society?

If we take a look at photos of the same working processes, everyday activities, cultural or urban landscape with a time difference of 100 or 50 years, we notice revolutionary changes. Revolutionary changes in the way things look, the way people behave and the way things work. Technology has penetrated everywhere. Even if unseen in foreground, it is definitely there in the background, making it all possible. But if we were to take a closer look at a photo of an elementary school classroom from 50 years ago and from the present day, we would notice very few changes. For most of the world, the teaching techniques of "chalk and talk" are still in place. We have all this technology surrounding us, all these gadgets and services, yet the very key aspect of all of our progress – the learning process – has been literally unchanged for a century or more. The school system as we still know and very much use it today was created in the industrial era. It was back then that parents were no longer able to look after their children at home as they started working in factories, which, at the same time, required specifically skilled labour to be trained for the job. These were the two key factors in establishing a school system for everyone. The school system, which was based on the principle of "one size fits all", put together individual children in clusters of 20 or 30, regardless of their talents, motivation, background or any other characteristics, and offered them the same content in the very same way. Although no two single individuals are alike, this system enforced the perception of everybody being the same. The school system of the industrial era evolved slightly in the post-industrial period and reached its zenith by the mid-20th century, but failed completely to change, modernise, update and adapt to the coming of the information and knowledge societies. Suddenly, the technology bubble exploded. New gadgets and new ways of doing things were available, and, above all, there was immediate access to all this information available in so many ways from everywhere. Learners were eager to pick it all up, leaving their teacher, mentors or tutors far, far behind.

Andrej Gregorc

Knowledge and skills credibility gap

The new, technologically based society was immediately adopted by companies and their employees. They had no choice but to adapt to new methods of doing business if they wanted to survive on the market. The school system, however, does not compete on the market at all, so felt no immediate threat or need to change. Most curricula are still filled with matter merely to fill them, rather than with the goal of providing learners with the knowledge and skills actually required these days. Schools that were supposed to support and nourish diversity, and listen to each

TRAINING CONTENTS

Network Technologies

- Basics of TCP/IP and Ethernet
- MPLS I
- MPLS II
- Virtual Private Networks
- QoS in IP/MPLS
- Transport Networks
- Metro/Carrier Ethernet Technology
- Optical Access Networks
- Security in IP
- IPv6 I
- IPv6 II
- Security in IPv6
- Routing in IP Networks
- Multicast in IP Networks
- Mesh and »Ad-hoc« Networks
- Peer-to-Peer Systems
- Convergent Networks Management
- Telecommunications Management
- Telecommunications Engineering
- ATM I
- ATM II

Signalling and Communication

- Architectures
- NGN Signalling
- PSTN Signalling (SS7)
- SIGTRAN
- Voice over IP
- Session Initiation Protocol
- Next Generation Networks – NGN
- IP Multimedia Subsystem – IMS
- IMS and NGN Service Creation Environment
- Service Development in IMS/NGN
- Security in VoIP/IMS
- IMS Authorization, Authentication and Billing
- 3Play Services

Wireless Technologies

- Positioning Services and Navigation
- Satellite Communications and Positioning Services
- Basics of RFID and NFC
- Basics of Bluetooth and ZigBee
- Wi-Fi Networks
- Wi-MAX Networks
- Terminal Equipment GSM/UMTS
- Data transfers in 3G/4G Networks

Cisco Network Academy

- CCNA 1 – Network Fundamentals
- CCNA 2 – Routing Protocols and Concepts
- CCNA 3 – LAN Switching and Wireless
- CCNA 4 – Accessing the WAN
- Cisco WLAN
- CCNA Security
- CCNP 1 – Building Scalable Internetworks
- CCNP 2 – Implementing Secure Converged • Wide-Area Networks

Information Technologies

- Java I
- Java II
- Java III
- Java IV
- PHP
- WEB 2.0
- Basics of Linux
- Planning for All and E-accessibility

Hardware and Embedded Systems

- Hardware Platforms x86
- Embedded Systems

Multimedia Technologies

- IPTV
- Basics of Video Production
- Recording and Editing
- Digital Video Encoding
- TV Production and Playout Systems
- Digital Video Broadcasting and Mobile TV
- Flash CS4 I

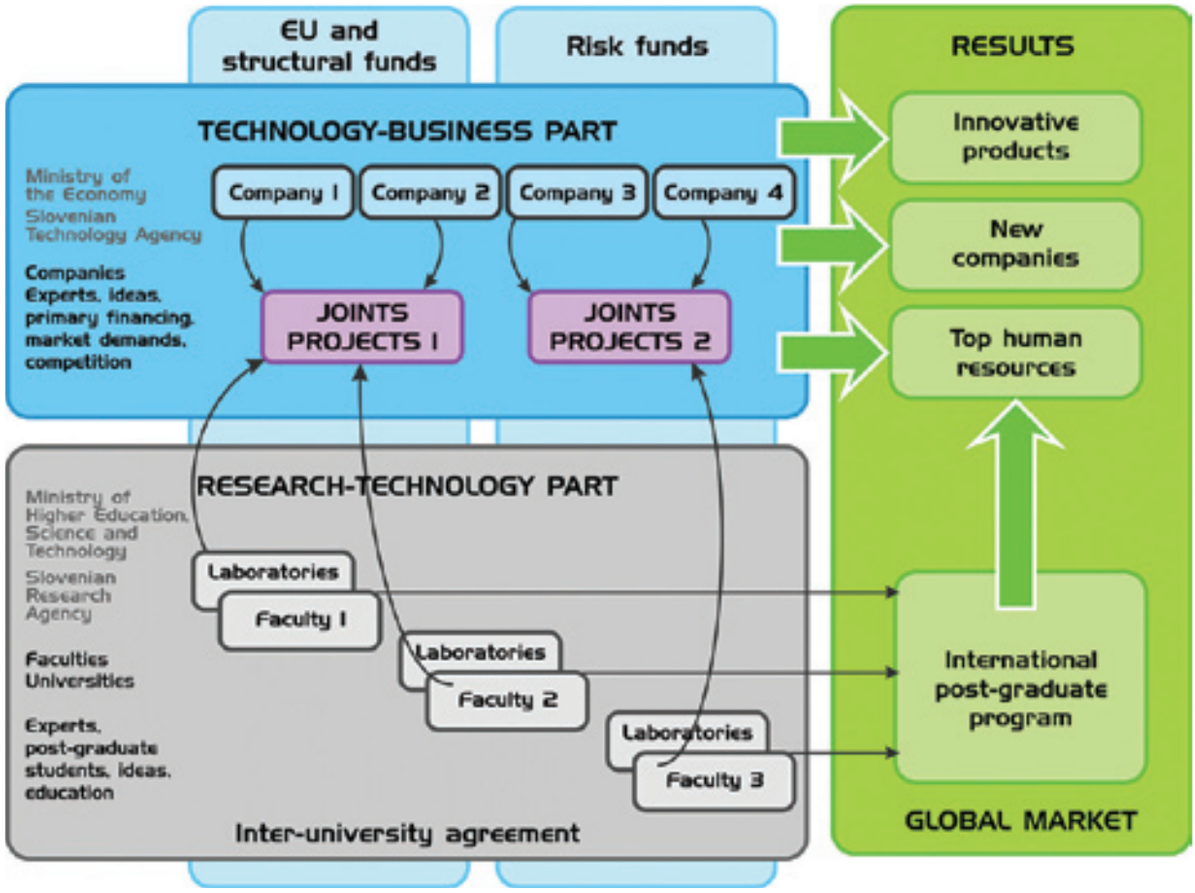
individual's needs, still prefer to try to unify the learners, often disregarding and denying them the right to disagree, think differently or perceive things in another way. It is, of course, important for the school system to provide learners with the ability to read and write flawlessly, but mastering reading and writing should not be the only goal of educating an individual. The school system should allow and encourage individuals who can go beyond the reading and writing pattern and are able to think and express themselves in other ways or by other means. The inability to differentiate between the learner's "ability to learn" and the "talent of being gifted" can forever ruin an individual's career and destroy a bright future. Above all, the current school system is not competent to give learners a vision of the world as it could be, instead merely offering them the world as it is. Along with a marking system based on the reproduction of acquired fact to a certain percentage level, this is what makes the current

school system in most of the world completely out of touch with reality. Such a system can not accurately respond to the needs of the market, the needs of the economy, the companies, institutions, or the knowledge and know-how think-tanks. It can only continue to produce candidates that were able to achieve a certain degree of reproductive capability within a certain field, in many cases mastering outdated content. What we face today is a huge ""credibility gap" between the skills and knowledge that companies need and expect from young people at the end of their formal education and what the school system actually offers. It is this credibility gap that has forced companies to start carrying out their own tests, pre-employment selections or establishing their own methods for grading the capabilities of candidates. At this point, luckily, the school system responded and realised that it was high time for a change, or, more accurately, a revolution.

Professor Dr Janez Bešter, Head of the Laboratory for Telecommunication

Challenges of present-day education

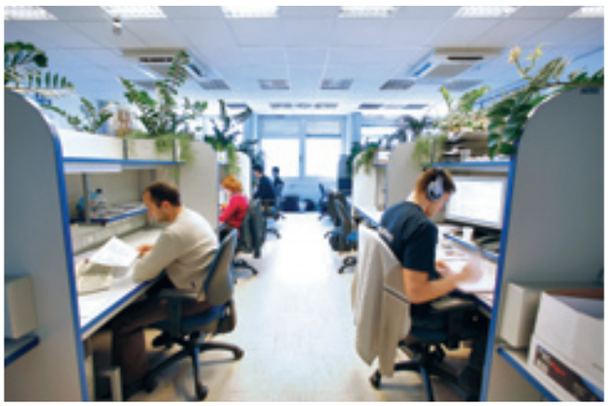
Information and telecommunication technologies and services (ICT) have become an essential part of the social and economic infrastructure. It is estimated that ICT contributes over 40% of productivity growth in Europe and accounts for 4.5% of European GDP,



or even more if added value in other sectors is taken into consideration. Advanced information and telecommunication technologies and solutions are developing at an extremely high pace, and are nowadays present in all areas of life, work and spare time. The information era, especially in its technologies for communication, has greatly changed the behaviour and the everyday lifestyle of the society, and has also had a drastic influence on the process of education and knowledge acquisition. In the past, obtaining a formal education at a university level more or less sufficed for the whole career, with knowledge only required to be occasionally updated and refreshed. Over the past few decades, the "life expectancy" or the usable duration of acquired knowledge has been shortening continuously. Reaching the formal university education level now represents only an initial stage in the process of sustaining a knowledge level, and especially the ability to use acquired knowledge in the following years. The latter requires constant contact with an individual's professional environment, knowledge and know-how expansion, upgrading and specialisation. The former once-in-a-lifetime process of schooling has been replaced with a life-long process of education and continuous learning. Simultaneously, the enormous amount of information available and the large spectrum of skills needed to successfully perform a highly demanding professional task have shifted the emphasis from narrow, specialised knowledge fields to wider, interdisciplinary or multidisciplinary knowledge and abilities. Information formerly only available in study books can now be accessed anytime from anywhere, as well as updated with new findings almost instantly. The ability to quickly find, interpret and critically use all the information available has become the key aspect of digital literacy. Informal knowledge exchanges and contacts through various online social networks, as well as numerous websites with user-generated content have saturated the time which was dedicated to learning "the good old way" in the past. We must not be over-enthusiastic about the new trends. However, fearing or blocking access to sites of this type results in just the opposite effect to that intended. The timeframe of the workday has changed from 9–5 to almost 24 hours, and this must adequately be mirrored in the availability of educational content with the help of distance-learning technologies. The recent rapid and ongoing political changes in the larger European region, and globally, which have enabled unrestricted flow and exchange of people, goods, ideas and knowledge, have greatly stimulated the intermingling of different sciences as well as cultural diversity. All of the above-mentioned processes are strong contributing factors, which must drive universities, faculties and other scientific, research and educational institutions towards establishing types of educational and research environment that will better address and serve the needs and challenges of modern educational and research trends.

Connecting ICT technologies, various teaching approaches and top-notch lecturers

The Laboratory for Telecommunications at the Faculty of Electrical Engineering realised the potential of new technologies in education at the very beginning. Already, in the early and mid-90s of the previous century, the laboratory was working in the direction of integrating the latest technologies into educational processes, as well as changing methods of teaching, assessment and communication with learners. The laboratory was among the first in the country to establish its own web page, with relevant information from the ICT field and learning content available on-line. In the late 90s, the laboratory developed and successfully used a complete e-learning system named E-CHO, which consists of a Learning Management System (LMS) as well as a Learning Content Management System (LCMS) and was the result of laboratory's own research, knowledge and several years of development. The platform supports a state-of-the-art distance-learning system, which can be adapted for any content in any field or for any customer. The system is constantly being upgraded and updated with the latest technological developments. The laboratory's solutions were introduced into a number of large Slovenian corporate environments, such as Telekom Slovenije, Nova Ljubljanska Banka, Mobitel, the Ministry of Defence and others. The laboratory also cooperates with academic and school environments in Slovenia and abroad. LTFE is the co-ordinator of the national project "Complete e-learning



Introduction on the National Scale in Slovenia", which aims to develop a "Slovenian National E-learning Strategy".

The direction of knowledge interweaves with project work and entrepreneurial challenges and is being complemented with multimedia training. We are able to maintain this mode of operation thanks to the experienced team of laboratory associates from various fields of expertise, extensive pedagogical experience, numerous successfully implemented projects, excellent conditions and equipment for research and development, topped with 60 years of presence and experience in the field of ICT in Slovenia. Besides regular faculty work with students, the laboratory now offers over 50 different courses, which are organised as training, workshops, lectures, demonstrations or laboratory work, all complemented and supported by e-learning, especially as a pre- and post-course activity. With all the technological possibilities, it is, however, important not to forget the basic relationship of student-tutor interaction. At LTFE, we always strive to provide our customers and individual learners the best possible combination of ways and methods of training, tailored to their specific interests, needs and characteristics. Our premises feature the latest available technology, in lecture halls and a multimedia centre, as well as in laboratories and research rooms.

The Advantages of "Real Learning" with LTFE

The broad spectrum of educational activities offered by LTFE is based on decades of successful work in research and development projects. The results of these projects and the technologies used are directly incorporated into educational activities, which therefore mirror real-life situations in existing business projects. There are no professional lecturers within LTFE. All lecturers, tutors, mentors and teachers working with LTFE are constantly working on research project in the fields they cover when lecturing, which assures that they are highly trained practically as well as theoretically, and can give learners an insider's view of the subject. The experts and researchers working with LTFE all have extensive research and pedagogical experience and mostly cover several different fields or topics, which allows for blending of different content in educational activities to provide exactly what learners expect. The educational activities of LTFE include distance learning (especially as part of pre- and post-training), along with lectures, workshops with hands-on experience, and demonstration and laboratory work on state-of-the-art equipment. The distance-learning system enables participants to access the notes of the training, as well as abstracts and other training-related material online. They can keep in touch with themselves as well as with their mentors after the end of the training. This means that participants in LTFE training activities can always refer to LTFE experts for further questions, clarification or practical advice, even long after they have taken part in an educational activity. All LTFE training activities are carefully chosen to reflect the latest technological trends and needs of the ICT field and are constantly revised, updated and upgraded. Working in small groups makes activities more personal and allows tutors to address the needs of each individual participant. The level and depth of the content within training can always be adjusted to the knowledge level and previous experience of the participants. After successfully completion of the training activity, the Faculty of Electrical Engineering issues a certificate to each participant, which can be an important reference in their careers.

OpenLab – Encouraging young people to careers in relevant fields

The economic downturn the world faced in 2009 risks endangering and further limiting investment into ICT research and development, which is why the government must intervene and provide the means to prevent this happening. In times of crisis, intellectual capital and knowledge gain in importance, which is why such fields require even more funding to further enhance their potential. Cooperation is again the key word, regardless of whether it is among companies, institutions, faculties or independent scientists. Talented young individuals should be encouraged to take an active part in technological development, must get the best possible education the school system can provide, and should be steered towards the most potentially rewarding fields within the economy. The Faculty of Electrical Engineering, despite the looming recession, opened OpenLab in June 2009, as a centre for stimulating creativity among young people in the city of Kranj. The centre offers young people a creative environment, opportunities for project work, research and entrepreneurship experiences, promotes innovative technologies and provides a gathering place where youngsters can meet their friends as well as ask questions and discuss their ideas with tutors or talk to ICT experts. The centre stimulates interdisciplinary knowledge and careers within ICT, and enables young people to spend their spare time in a creative manner. OpenLab is a non-profit organisation with open doors to every individual who can bring their own technological ideas or input. It

was established with the support of high-tech companies of the region, as well as from the rest of the country. It boosts top-quality equipment and appropriate space for informal gathering. Its activities comprise numerous workshops, lectures, seminars, summer schools, presentations, technology evenings, project work and competitions. All of the latter are designed to support talented young people on their way towards becoming leading experts in the ICT of tomorrow. After successful completion and final implementation of the pioneering project in Kranj, several other similar centres are scheduled to open across the country, especially in educationally underprivileged regions.

ICT as the key element of future global development

Besides the problem with the education system, human society today faces other problems and challenges, which can, if left unresolved for too long, even endanger its own existence. With many global issues requiring immediate attention, ICT technology can be used extensively to facilitate the required efforts. The user in such work must be absolutely considered as the centre of the development model. The technology must only provide or help to achieve what the user requires. One of the most evident applications is in the problem of global climate change, which cannot be denied or ignored. Even if all current scientific predictions of climate change are wrong, the collateral damage of fighting against it is almost non-existent. However, if only part of the predictions are correct, not responding or reacting is likely to lead to unforeseen, and perhaps even lethal, consequences. Combating global climate changes gives mankind a unique opportunity – to fight against itself. This is the only "war" in the history of mankind in which there is no enemy, or no other side, only "us". This gives us the again never before seen opportunity to face ourselves, our lifestyles and to forever drastically change our patterns of social behaviour. In this fight, ICT can be a leading element. Technological development must take into consideration nature, its cycles and characteristics. It cannot and should not only be short-term profit-oriented. Electrical and electronic devices and services must be created in such a way that they can be used over a longer period of time, at least several years, and can only be upgraded if required. The area of e-learning, based on and integrated with modern ICT technologies, is one of the main driving forces of sustainable development and the progress of an information-based society in Europe and the world. E-learning applications and related content support the rise in information and electronic literacy and enable a decrease in the digital divide across the world. Available ICT tools, services and technologies must be used to a greater extent to introduce paperless business operations, a decrease in migrations and business travel and digitalisation of all aspects of operations and management. It is estimated that ICT can contribute between 15 and 40% to reductions in greenhouse gas emissions due to implementation of intelligent transport systems, smart buildings, improved management of energy networks, better logistics and a reduction in travel. ICT technologies should play a crucial role in the transition of developing countries, since they can provide the necessary support to omit one or more development stages and therefore greatly reduce environmental effects. ICT is also indispensable in facing modern-day European social challenges, e.g. sustainable health care, comfortable ageing, enhanced safety, security and privacy, energy efficiency, smart traffic systems, etc.

[TURN ON INNOVATIVITY]

Contributing to the Global Research Efforts in Developing Internet Technologies and Applications

Laboratory for Open Systems and Networks, Jožef Stefan Institute

The Laboratory for Open Systems and Networks was established in 1992. The research team attached to the Laboratory for Open Systems and Networks is involved in R&D streams concerned with the development of next-generation networks and Internet-related technologies and services, especially those that assure efficient and pervasive life-long learning. The laboratory is implementing research work within the "Future Internet technologies: concepts, architectures, services and socio-economic issues" programme funded by the National Agency for Research and Development. Research activities are also carried out within the EU FP7 projects P2P-Next, Eiffel and GLOBAL, the eContentPlus ICOPER and OpenScout projects, the e4VET project from the Leonardo da Vinci programme, the TwinTide project from the COST programme, and in several other national projects. The main focus of research is the area of technologies and services in advanced networks, technology-enhanced learning, and information security, privacy and dependability. Research results are transferred to Slovenian industry and students at undergraduate and graduate levels at the University of Ljubljana, University of Maribor, and the Jožef Stefan International Postgraduate School.

Members of the Laboratory for Open Systems and Networks

Concepts, architectures, technologies and services of the future Internet

Research and development of novel Internet technologies and services has always been at the heart of the activities of the Laboratory for Open Systems and Networks. Members of the laboratory established the national academic network with international connectivity of e-mail services in 1989 and brought the Internet to Slovenia in 1991, established the first international ATM connection in Slovenia in 1996, and made a significant contribution in the deployment of active networks based on IP and on GRID systems.

Currently, the group is focusing research on identification and development of major concepts and architecture design of the Future Internet. This research is being carried out within the EU FP7 project **EIFFEL** (**E**volving **F**uture **I**nternet for **E**uropean Leadership). EIFFEL is working within the "think tank" group of European and world wide scientists and experts from the most famous universities in the world, such as MIT, Stanford, Berkeley, Oxford, Cambridge, Aachen, Tokyo University and others. The results of EIFFEL are being published as White Papers and discussion is moderated at the Future Internet "Fipedia" website (http://www.fipedia.org). As part of this project, in 2008 the laboratory organised and set up the European Assembly on the Future of the Internet, which gathered everyone in Europe from academia and industry working in this field. A total of 62 project teams and their co-ordinators from FP7 and managers from the rest of the world, e.g. the NSF from U.S, AKIRA from Japan, have set up the framework for further development of the Internet and related fields such as e-mobility, networked media, the Internet of things, and networked software and services. Attendees of the conference have adopted the Bled declaration on a European research strategy and approach to the Future Internet, which is considered as vital infrastructure for the future European economy. In addition to this, the Future Internet Forum was set up by members representing EU Member States with the goal of continuing the co-ordination efforts of European R&D in that area. The first Future Internet Assembly (FIA) has adopted the Bled Declaration on the Future Internet.

Opening of the conference The Future of the Internet

Current Internet infrastructure in the developed world is used for simultaneous transmission of live events to millions of people (broadcasting), and the approach to audio-visual media is moving from collective and passive to personal active behaviour. In this area of the Future Internet, the research activity of the Laboratory members is oriented towards the development of an open source, efficient, trusted, personalised, user-centric and participatory television and media delivery system with social and collaborative connotation using the emerging Peer-to-Peer (P2P) paradigm. This research is part of the EU FP7 **P2P-Next** (Next Generation Peer-to-Peer Content Delivery Platform) integrated project, which has the goal of developing a next-generation P2P content-delivery platform that takes in account the heterogeneous and demanding environments of next generation networks and at the same time considers the demand for low-cost delivery of professional and user-created content. The laboratory contribution to the project is focused on provision of the security and trust-building services of the platform.

An important contribution in the area of e-infrastructures that are building a sophisticated service for R&D in Europe and across the world is the **GLOBAL** (**G**lobal **L**inkage **O**ver **B**roadb**A**nd **L**inks) project. The project is building a virtual conference centre using advanced communication technologies and concepts in support of an efficient and world-wide accessible e-infrastructure With the ISABEL videoconference tool being part of

President of Slovenia Danilo Türk at the MeRLab project stand

the open source site known as the Global Plaza virtual conference centre, the GLOBAL partners are connecting infrastructure in South America, India and Africa and providing, in addition to e-infrastructure services, the necessary spread and transfer of knowledge.

Most of the activities related to the Future Internet projects are part of the concentration meetings and other EU-organised event. However, the results are also published in relevant journals in the field. The created knowledge was also used in support of the design of the wireless broadband network for the city of Ljubljana.

Technology-enhanced learning

Members of the laboratory are working intensively in the area of technology-enhanced learning and usability evaluation of IT learning or security services, along with tools such as authentication mechanisms. A powerful portal was developed in cooperation with European university partners for exchange of learning resources that enable a personalised search adapted to the needs of enterprises and the particular learner. The system enables selection of the most appropriate learning environments. The portal is known as the **EducaNext portal** and the selection tool as the **HCD Suite** (Suite for Human Capital Development in companies). The privacy issues of the HCD Suite were developed by laboratory members within the **ELENA** (Creating a Smart Space for Learning) project from EU FP6.

The laboratory team was involved in several EU projects in the area of technology-enhanced learning. Among them, special attention is deserved by the EU FP6 **PROLEARN** (Network of excellence in professional learning) network of excellence and the **iCamp** (Innovative, inclusive, interactive & intercultural learning campus) project, where an innovative e-infrastructure the **iCamp Space** – was created enabling collaboration and social networking across systems, countries and disciplines. The handbook **"How to use Social Software in Higher Education"**, prepared within the iCamp project was designed and published with the aim of promoting and understanding the new Web 2.0 technologies as an innovative learning technology in education. The laboratory has also approached the problem of the large number of e-learning repositories, which makes the problem of finding and selecting the right learning resources for particular learning goals and needed competencies difficult. The solution to this problem was developed through a framework enabling personalised access to educational networks such as the Edutella network. This approach enables the learner to find the optimal resource based on the learner's personal profile. The approach and the educational dis-

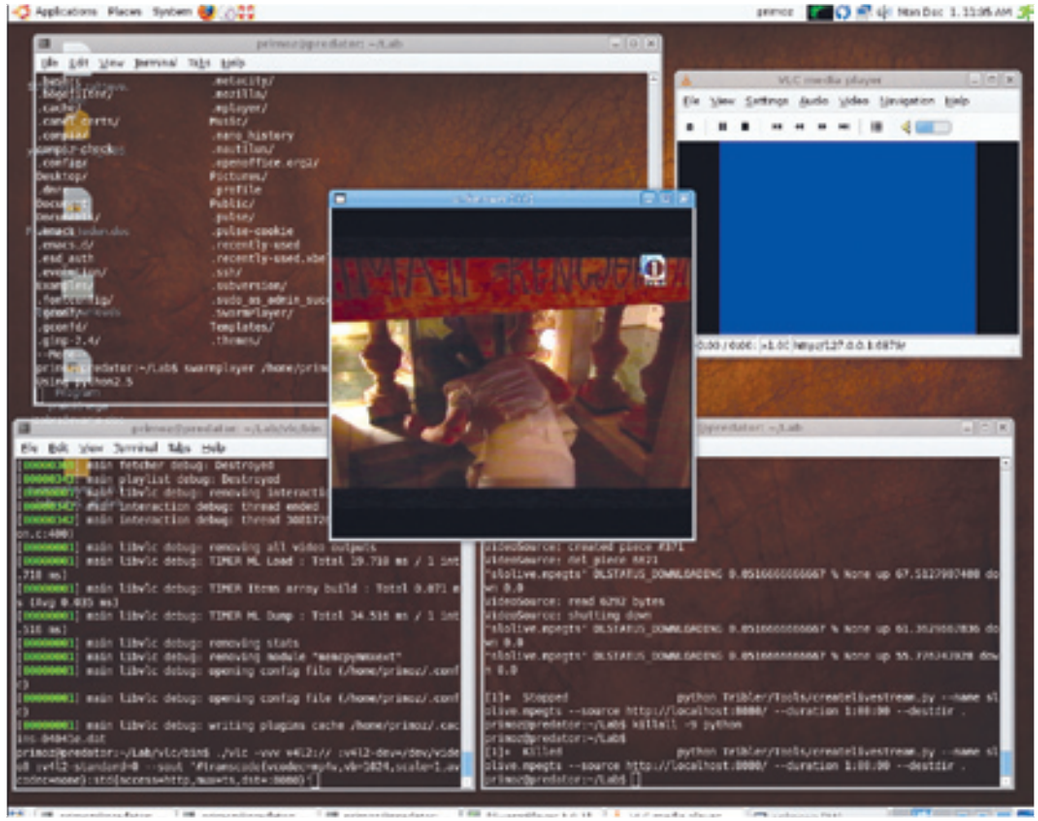


Figure 3: Knowledge transfer by means of a videoconference system

Figure 4: E-learning tools and solutions developed by the laboratory

tributed repositories are being further developed in the European eContentplus **OpenScout** project (Skill-based scouting of open user-generated and community-improved content for management education and training).
To increase the effectiveness of technology-enhanced learning, a bridge between competency definitions and educational content needs to be developed. Learning outcomes and competencies in particular are the main research theme of the **ICOPER** (Interoperable Content for Performance in a Competency-driven Society) project. Here, the members of the laboratory explore and look for solutions of problems that appear in learning outcome-based learning, such as specification and formal description of learning outcomes, formal description of a learning process, preparation of and search for units of learning in line with expected learning outcomes, and evaluation of the obtained skills and competencies. The project is evaluating technology-enhanced learning standards (e.g. IMS LD or IMS QTI) and is developing good practice approaches to using these standards. The findings of the evaluation and the good practice studied are expected to form part of the updated e-learning standards and components for a new reference model for competency-driven learning.
Another European e-learning project co-ordinated by the laboratory is the e4 VET project. This project is primarily aimed at promotion of the attractiveness of the VET (Vocational Education and Training) schools through the establishment of an **EduCenter** (http://www.educanter.eu), by building a network of different open-source educational systems and tools. The project helps teachers in general and vocational subjects, along with teachers specialising in adult education and training, to learn about innovative and easy-to-use tools for developing e-learning materials and access to the broad variety of e-learning materials.

A similar project with a slightly different aim in this area is the **MeRLab** (Innovative Remote Laboratory and the E-training of Mechatronics) project, which is part of the Leonardo da Vinci Programme – Transfer of Innovation. This project has developed good practice in the field of vocational training of mechatronics. The good-practice approach was based on the development of an e-learning-based course in the area of mechatronics. The course involves theoretical and practical training lessons that can be entirely conducted on-line. Practical work with the learners was performed using an innovative virtual laboratory that supports real mechanical-electrical and programming-related experiments similar to those in a real laboratory.

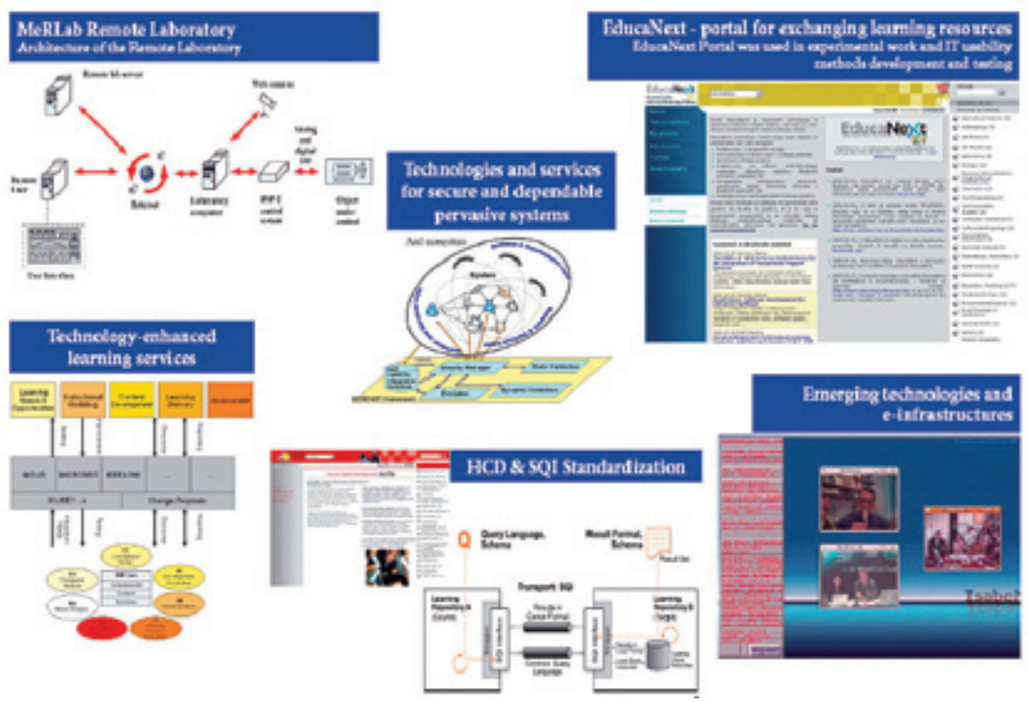


Figure 4: E-learning tools and solutions developed by the laboratory

Usability studies for IT tools are mainly performed within the COST project TwinTide (Towards the Integration of Transectorial IT Design and Evaluation), which has been recently launched. The aim of the project is the development of more sound approaches and methods based on measurements and testing in the area of human-computer interaction. The tools and methods to be developed are intended for use in the ICT industry.

Security, dependability and privacy in information systems

Provision of security and privacy services is crucial for the modern information society. This subject is a part of continuing research by the laboratory members who created the first public-key certification authority in Slovenia, in the mid 1990s. They also contributed to the composition and adoption of the Slovenian Law for E-commerce and Digital Signatures in 2000. Recent relevant research results in this area include security architecture for active network nodes (for active networks such as GRIDs), distributed and programmable firewalls (manageable from distributed sites in a broadband network), trusted personalisation methods in technology-enhanced learning systems with support for privacy protection, a service for secure long-term archiving of digitally signed documents, and secure protocols for communication with trusted archives of electronic digitally signed documents.
The **LTAP** (Long-term Archive Protocol) protocol that defines communication between a user and secure electronic archive i.e. syntax and semantics of exchanged messages such as archival services requests, was adopted as an Internet standard and is currently being standardised in the **IETF LTANS** (Long-term Archive and Notary Services) working group.
Quantification of the necessary investment of an enterprise in security technology and a standard approach to security-information investment assessment have been developed as a model implemented in a software tool. This research was carried out to meet the needs of business organisations. The findings were published in influential scientific journals.
These results have contributed to the further involvement of laboratory members in the development of services for next generation networks, where flexible security provision based on the relevant environment (e.g. mobile) and user requirements is becoming crucial. The implemented active node

security architecture, for example, provides necessary security services in active networks, in particular in ensuring the integrity of network elements such as active internet packets, providing authentication of the packet origin and authorisation and security policy enforcement. The developed distributed and programmable firewall enables distributed detection of threats and an automated triggering of distributed countermeasure and prevention tools. The main properties of modern heterogeneous communication systems, such as pervasive communication systems, systems with ambient intelligence or systems based on the Internet of things, are ubiquitous and represent a complex interconnection of services and devices, with a dynamic nature and system flexibility as well as service awareness of the user's context. The privacy, security and dependability issues of such systems were investigated in the integrated EU FP6 SERENITY (System Engineering for Security & Dependability) project. Here, the research was focused on development of standardised security patterns designed to be embedded in various network services and applications. Dynamic security management and control was also core work in the **VIZIPIN** project, where some solutions adapted to modern military needs were provided.

Figure 6: Borka Jerman Blažič receiving her award

Members of the laboratory won best paper awards in 2007 and 2008 at the international Conference on Digital Society, and Borka Jerman Blažič, with co-authors, in 2008 achieved the best-ranked published paper, entitled *Factors and Sustainable Strategies Fostering the Adoption of Broadband Communications in an Enlarged European Union,* among all researchers in the Faculty of Economics of the University of Ljubljana.

Figure 7: Web page of the Video-conferencing Centre (http://konferenca.e5.ijs.si)

Establishment of the Infrastructure Centre for Video Conferencing and organisation of complex distributed events

Under the **Infrastructure programme for research organisations 2009 in Slovenia,** a **Video Conferencing Centre** (http://konferenca.e5.ijs.si) was established. The main objective of the Video Conferencing Centre is to provide support services for better communication between members of research programmes, especially in cases where the programmes are multi-disciplinary and where multiple geographically distributed institutions are working together.

The Video-conferencing Centre provides support of **simple online communication** and **advanced online communications** services, which allow participants direct view and co-operation at a distance across Europe and around the world for complex events (including many continents, many sites and the use of multimedia tools simultaneously).

The BLED Declaration:

Towards a European approach to the Future Internet

Current Internet: Success & Challenges

With over a billion users world-wide, the current Internet is a great success – a global integrated communications infrastructure and service platform underpinning the fabric of the European economy and European society in general. However, today's Internet was designed in the 1970s for purposes that bear little resemblance to current and foreseen usage scenarios. Mismatches between original design goals and current utilisation are now beginning to hamper the Internet's potential. A large number of challenges in the realms of technology, business, society and governance have to be overcome if the future development ofthe Internet is to sustain the networked society of tomorrow.

Future Internet: Vital to continued economic Growth in Europe

In the future, even more users, objects, services and critical information infrastructures will be networked through the Future Internet which will underpin an ever larger share of our modern and global economies. It is therefore time to strengthen and focus European activities on the Future Internet to maintain Europe's competitiveness in the global marketplace.

A significant change is required and the European Internet scientific and economic actors, researchers, industrialists, SMEs, users, service and content providers, now assert the urgent necessity to redesign the Internet, taking a broad multidisciplinary approach, to meet Europe's societal and commercial ambitions.

Future Internet: Addressing the Challenges through EU Collaboration & Cooperation

EU member states have already committed, through the renewed Lisbon Agenda and the i2010 initiative, 9.1 billion of funding, as part of a public-private partnership, for ICT research over the duration of FP7. However, we must ensure that, within this, continuous and long term support is given to the design of the Future Internet as a key element of the future networked society. It is of strategic importance for Europe to fully engage in the conception, development and innovation of a Future Internet ensuring the long term growth of the ICT sector, full support to an ICT based economy, and the elimination of the digital divide for all citizens.

The research projects assembled here in Bled represent the first phase of this public-private partnership, a joint investment of over 400 million, that recognises the challenges above and emphasises a concerted and comprehensive process of redesign, based upon novel network, service, trust, security and content technologies together with strong initiatives towards new innovations in societal, governance and service domains, in order to ensure that the Future Internet fulfils its potential.

More specifically, building upon the obligations of our individual project contracts and the goals of the Strategic Agendas of the European Technology Platforms, we confirm our ambitions include:

Fostering Favourable Conditions through Coordinated Action

- Coordinate our efforts to foster cross-disciplinary innovation and creativity.
- Work together through a European Future Internet Assembly of research projects strengthening cross-discipline activity and optimising the impact of our actions.
- Cultivate and foster the skills and knowledge required to develop the Future Internet.
- Create the conditions for the deployment of services and service oriented systems.
- Communicate through open standards for Future Internet technologies and architectures.
- Open the European Future Internet Assembly to new projects and actors over time to widen the coordination and consistency of the action.

Jointly Designing, Developing and Experimenting

- Services and networking architecture for the Future Internet.
- Location independent, interoperable, coherent, consistent, scalable, pervasive, reliable, secure and efficient access to a coordinated set of services.
- Tools supporting collaborative business models and social network applications.
- Technologies ensuring the robustness and security of the networks, managing identities, protecting privacy and creating trust in the on-line world.
- Approaches and tools to leverage the full potential of the Internet of Things.
- Capabilities for supporting the creation, sharing, locating and delivery of new-media content.

Increasing Awareness at Policy Level

- Raise awareness of the economic, policy and regulatory issues as identified by the newly proposed European Future Internet Assembly, the UN Internet Governance Forum, the OECD and the European regulatory frameworks.
- Contribute to the definition of European positions within global forums and arenas.

Call for European action towards the Future Internet

To help us meet these major challenges, we call on the:

- European Member States to strengthen and coordinate their national R&D efforts and initiatives toward the Future Internet.
- European Commission to stress the vision and amplify the related R&D in order to drive Europe ahead of tomorrow's Internet transformations in the way we work, live, and interact.
- European Member States and the European Commission to support the creation and activities of the European Future Internet Assembly proposed in this declaration.

This declaration is endorsed by the following European Technology Platforms and European Research Projects*:

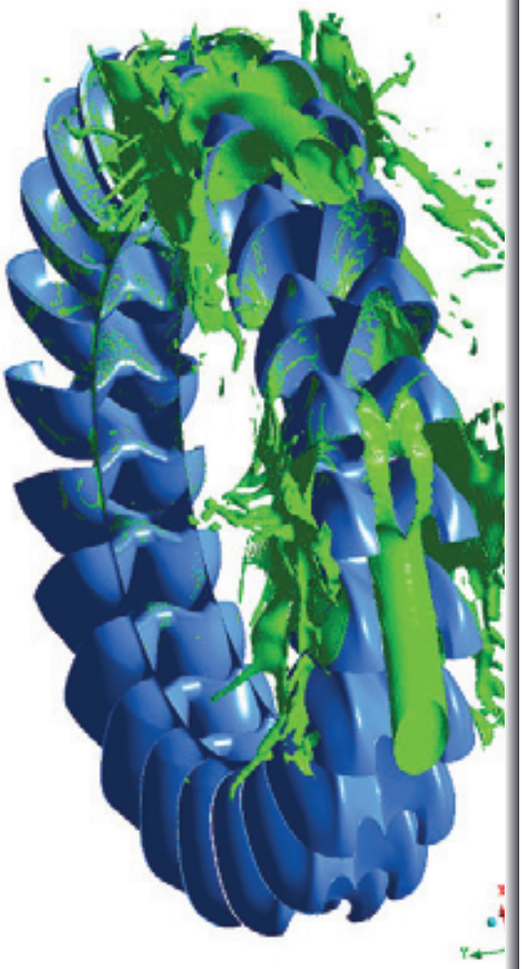
eMobility, NEM, NESSI, ISI and EPOSS

2020 3D Media	CHORUS	FAST
4NEM	COIN	FORWARD
4WARD	CONTENT	INTERSECTION
ADAMANTIUM	CuteLoop	IRMOS
AGAVE	DICONET	iSURF
ASPIRE	E3	m CIUDAD
AUTOI	eCRYPT II	MASTER
AVANTSSAR	EFIPSANS	MobileWeb2.0
AWISSENET	EIFFEL	MOBITHIN
CASAGRAS	eMOBILITY	MOMENT
CHIANTI	EURO-NF	NAPA-WINE

Ljubljana Supercomputing Centre – LSC Adria at Turboinštitut d.d.

High-Performance Computing in Hydraulic Machinery Research and Development

Andrej Lipej



Free surface flow analysis in Pelton turbine

Global demand for electricity is increasing by 3% annually on average and 6% in the high-growth countries of Asia. A growing world population, striving for a better quality of life, is demanding access to a reliable, low-cost electricity supply. Today, development is acknowledged as a basic human right. Without an adequate energy supply, there will be slow development, since energy is indispensable for all economic activities, and even for basic human needs. One third of the worldwide population has little or no access to modern clean energy. Energy is the key element in overcoming poverty. At the same time, providing more energy must not lead to greater global climate risk through uncontrolled emissions of carbon dioxide (CO2) and other greenhouse gases. The rising demand for electricity requires the use of renewable resources and increased energy efficiency, both helping to reduce the use of fossil fuels for energy production.

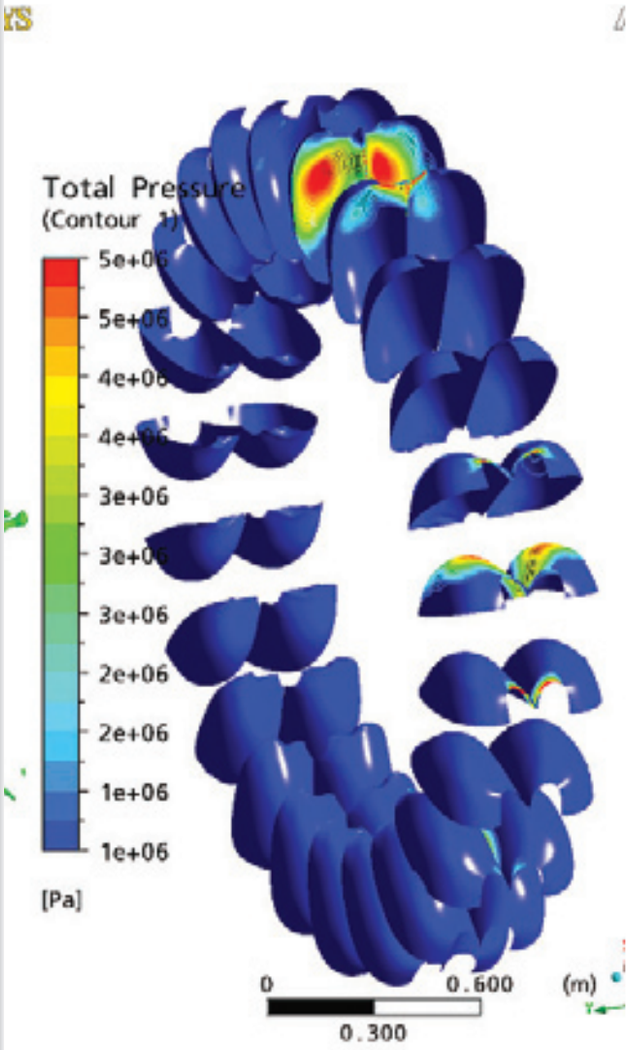
Doc. Dr Andrej Lipej, director of basic research & education and head of LSC Adria in Turboinštitut d.d.

Hydropower plays an important role in global energy production and produces almost 20% of the world's electricity. Research work in the field of hydraulic machinery is traditionally oriented around experimental methods. That is why all important producers have very well-equipped laboratories. The biggest companies all around the world even have several laboratories. There are also two independent laboratories in the world for model testing of water turbines and pumps capable of performing model-acceptance tests in accordance with international IEC standard 60193 – one at the Ecole Polytechnique Federale de Lausanne and the second at Turboinštitut.

To reduce the time-consuming, expensive and sometimes environmentally controversial experiments, in the last 20 years, great effort has gone into R&D in computational fluid dynamics (CFD). Turboinštitut has tracked the worldwide trends in CFD over time. In the mid 1980s, researchers at Turboinštitut started to develop their own CFD software, because at that time none was commercially available. The CFD department at Turboinštitut has passed all phases of the CFD development process and, in the last two decades, Turboinštitut has been one of the leading CFD companies in the field of hydraulic machinery.

CFD has been a useful tool in the design of all turbine parts for more than 20 years. Numerical analysis of water flow in turbines is important not only because it allows a reduction in expensive and time-consuming measurements, but also because it gives insight into the flow in all turbine parts. On the basis of numerical results, it is easier to find the reasons for low efficiency or for cavitation, and to improve the hydraulic shapes of all turbine parts. For small projects, model tests are too expensive and CFD analysis is the only way to foresee whether the required efficiency and cavitation characteristics of the prototype will be obtained.

The department of basic research at Turboinštitut has employees from different research areas. Currently, there are mathematicians, physicists and mechanical engineers. The group has seven members, but in the near future



three young researchers will begin on their PhD theses. One of the new researchers will be a computer and information-science engineer. The main activity of the basic-research department is work in the field of hydraulic-machinery design and CFD. Alongside the basic-research work, they also work on current commercial research projects for our customers worldwide.

In the last ten years, much progress has been achieved in numerical simulation of water flow in turbines. Before 1996, each component of a turbine was analysed separately. The results of numerical analysis of one component were used as the inlet boundary conditions for analysis of the next one. Guide vane and runner cascades were usually reduced to one periodical part. Such analysis was often successfully used for improvement of all turbine parts, but prediction of efficiency and cavitation was not accurate enough. Now, the possibility of simultaneous calculation of flow in rotating and non-rotating turbine parts, and the development of more powerful computers, have

Dr Vladimir Kercan, general manager of Turboinštitut d.d.

Francis turbine model on test rig

Turboinštitut d.d. (TI)

is a company with 60 years of tradition in R&D of hydraulic machines and more than 20 years of experience in Computational Fluid Dynamics – CFD. It is recognised as one of the world's leading industrial users of computationally intensive methods for engineering and research applications. Turboinštitut is one of only two independent laboratories in the world for model testing of water turbines and pumps capable of performing model-acceptance tests in accordance with international IEC standard 60193. The main activities of the company are water turbines and pumps R&D, design, manufacturing and engineering of equipment for small hydropower plants and co-operation with universities in Slovenia and South East Europe at a postgraduate level. On average, more than 90% of income is realised on foreign markets.

Six water-cooled racks with 2,048 processor cores

With the new supercomputer, Turboinštitut has a good opportunity to offer young researchers and postgraduate students of different areas, such as mechanical engineering, mathematics, physics, computer science etc., the chance to pursue their research work using the latest scientific equipment.

enabled coupled analysis of the whole turbine in a reasonable time period. By unsteady analysis using more advanced turbulent models, unsteady phenomena such as Von Kármán vortex shedding behind stay and guide vanes and rotating vortex ropes in the draft tube can be simulated. Using multiphase flow models, cavitation can be predicted and free surface flow in Pelton turbines can be modelled.

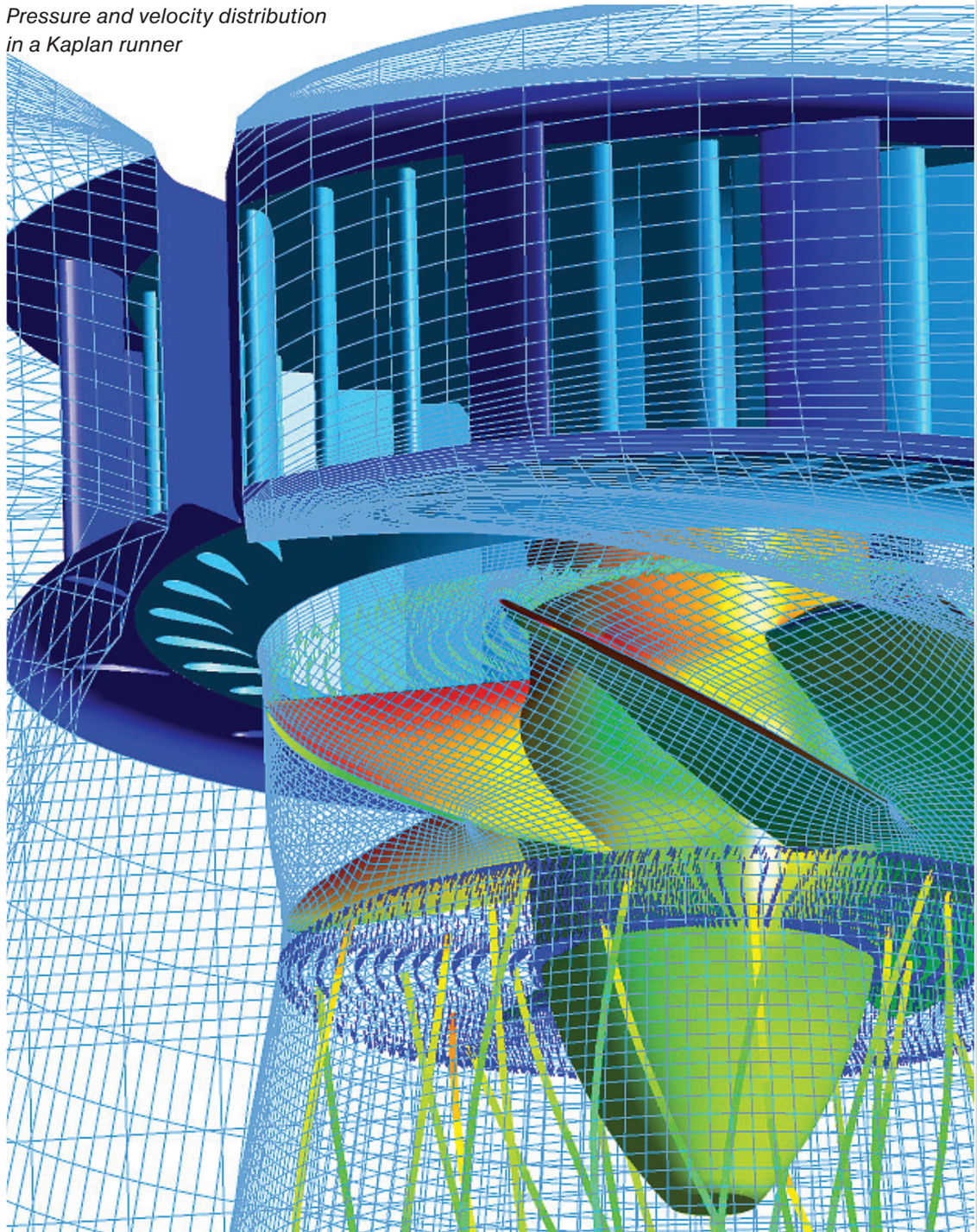
Considering its research-oriented future plans, Turboinštitut decided to establish a supercomputing centre with the most powerful computer in this part of Europe. LSC-Adria has been established with the purpose of promoting CFD in Slovenia and the whole region of Central and South East Europe.

The computer consists of: 2,048 processor cores – 512 quad-core Intel Xeon processors 5,520 2.26GHz CPU speed, 8MB L2 1,066MHz/60W, 4 TB RAM – 1,024 – 4GB (2x2GB) PC3-5300 CL9 ECC DDR3 Chipkill FBDIMM Memory Kit, 10 TB hard disc and, for high-performance computing communications, InfiniBand.

All computer infrastructure, including the computer room, electrical installations and air conditioning, allow for future upgrades in case of expansion of our activities. Besides work on current commercial projects in the company, LSC-Adria will also be used for research work in cooperation with Slovenian and foreign universities, post-graduate study and cooperation with industrial partners.

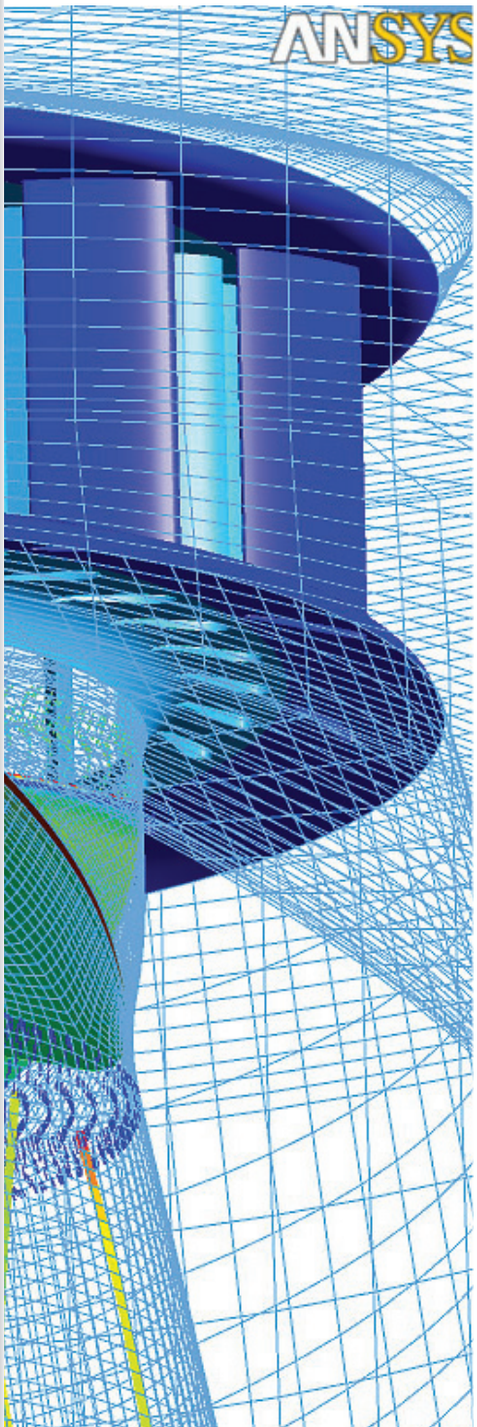
CFD plays an essential role in R&D work on hydropower sources. CFD is one of the most computationally inten-

Pressure and velocity distribution in a Kaplan runner



sive areas. The main problem of CFD is transformation of the system of partial differential equations, using a well-known numerical method (the finite volume method), to a huge system of ordinary equations. This system of equations should be solved in as short a time as possible. For solving these huge systems of equations, an effective parallel algorithm is necessary.

To obtain accurate results, very fine computational grids, appropriate turbulent models and the unsteady models are required. These conditions are responsible for a very long computational time, with calculations often taking several months. For modelling an unsteady phenomenon, the computational time is a few million times



Supercomputers are the Front Line for Current Processing Calculation Speed

Borut Robič

Since the 1990s, supercomputers have usually been massive parallel processing systems with thousands of processors combined with custom interconnections. Today, processors are off-the-shelf server-class microprocessors, such as the PowerPC, Opteron, or Xeon.

As with all highly parallel systems, the speed-up of a program using multiple processors is limited by the time needed for the sequential fraction of the program (Amdahl's law). For this reason, supercomputer designers devote great effort to eliminating software serialisation, and use hardware to address the remaining bottlenecks.

Borut Robič, Professor, Faculty of Computer and Information Science, University of Ljubljana

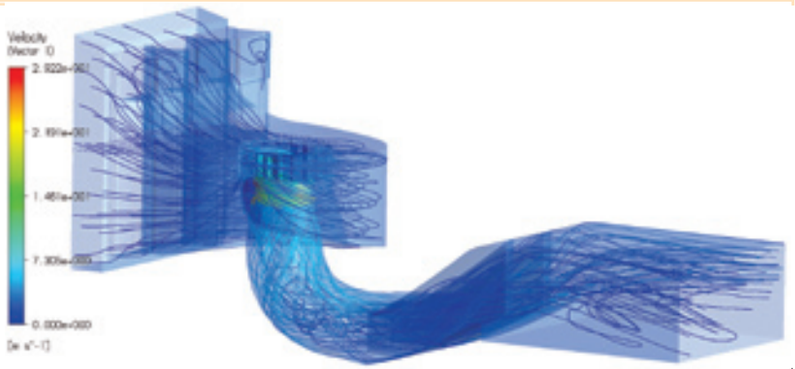
For example, a carefully designed memory hierarchy ensures that processors are kept fed with data and instructions at all times while the I/O system supports high bandwidth. To prevent any of the processors from wasting time waiting for data from other processors, it is critical to optimise a problem for the interconnection characteristics of the particular supercomputer. To do this, special libraries for sharing data between nodes must be used, along with special programming techniques.

All of this allows modern supercomputers to perform many tasks in parallel, as well as complex detail engineering. Nevertheless, supercomputers tend to be specialised for certain types of computation, usually numerical calculations. For example, supercomputers are used for highly calculation-intensive problems in quantum physics, weather forecasting, climate research, molecular modelling, and, of course physical simulations (such as computational fluid dynamics).

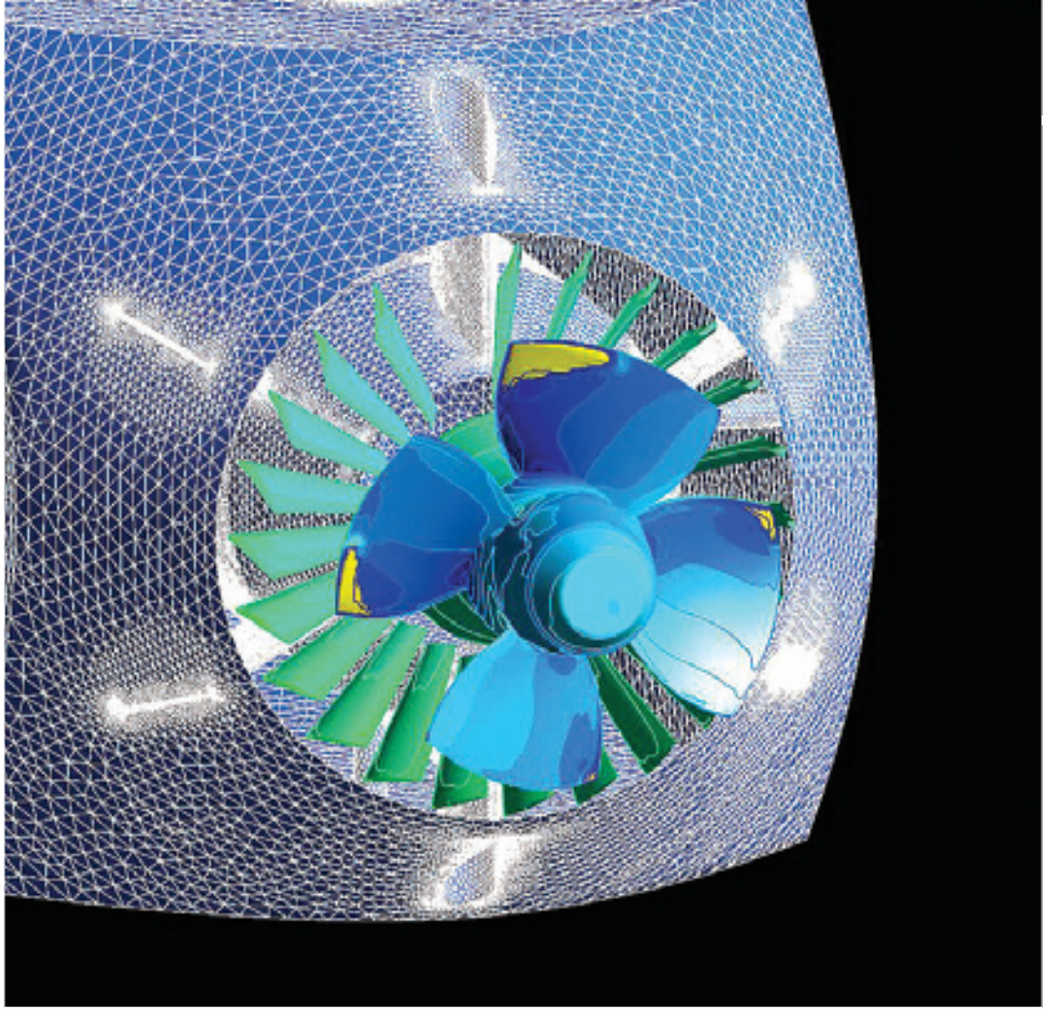
The speed of a supercomputer is measured in tera- or petaFLOPS (10^{12} or 10^{15} floating point operations per second), which are needed to accomplish a special benchmark involving LU decomposition of a large matrix. The TOP500 project, which ranks the 500 most powerful known computers in the world, is updated twice a year.

Today, particularly important in the design of supercomputers are the cooling problem (because large amounts of heat are generated during computation), latency minimisation (because data cannot move faster than the speed of light between the components of the supercomputer), and I/O bandwidth maximisation (because supercomputers consume/produce large amounts of data that must be retrieved/stored quickly).

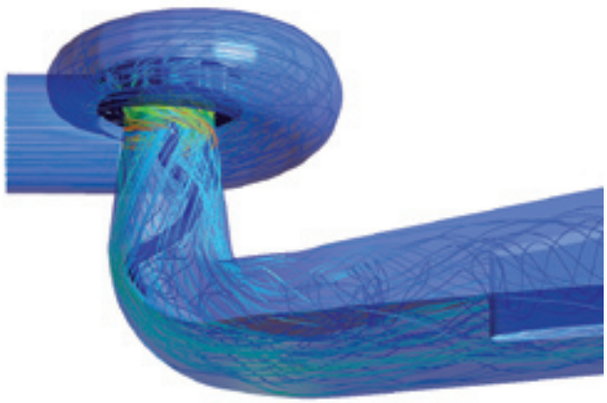
Finally, an easy parallel programming language to replace the standard Fortran and C programming languages is required.



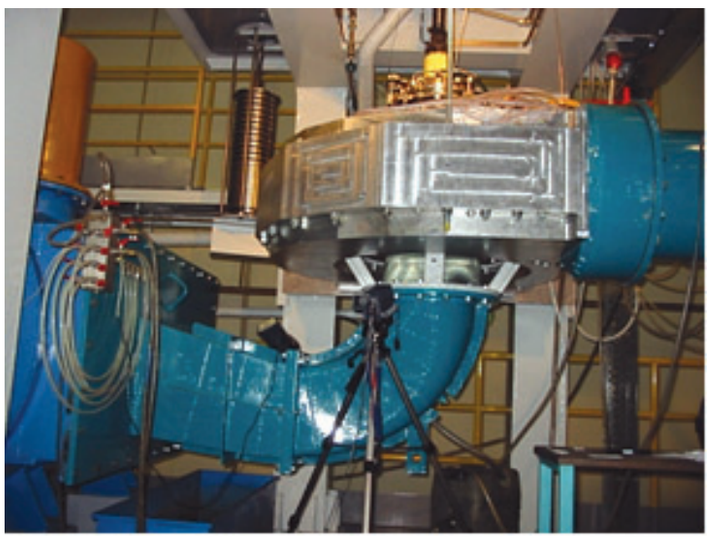
Flow distribution in a complete Kaplan turbine



Numerical analysis of cavitation in bulb turbine



Numerical prediction of the vortex in the draft tube of Francis turbine



Francis turbine model on test rig

longer than the real time of the analysed process. Our goal is to achieve numerical results in real time.

This can be attained using very fast processors or massively parallel computer clusters. At the moment, the speed-up in parallel processing when a huge number of processors are used is a significant problem. All commercial software has a linear speed-up for just up to approximately 100 processors. If we want to obtain computations 10 to 20 times faster with existing computers, a significant improvement of parallel computing is necessary. This is the way to reduce the computation time from a few months to some days. This improvement is very important for industrial projects.

Within industry, much numerical analysis and computer modelling are used in the development process. Virtual prototyping can reduce expensive, time-consuming and energetically wasteful experimental methods. In some areas, the complete characteristics can be predicted before any part of the product is produced. In cases where CFD is used in the development process, one of the available commercial software products can be used. Related industries that are possible users of this software include: turbo machinery, aerospace, automotive, chemical processing, civil engineering, electronics, environmental, defence, HVAC/refrigeration, industrial equipment, marine/offshore, medical, power generation, semiconductors and telecommunications.

An important area where CFD is used in the development process is energy, especially renewable energy sources. In the following decades, several hundred billion euros will be invested in this area, and Slovenian industry can take part in this business. Success depends on the quality of the newly developed products. Using up-to-date hardware and software, our industry can be competitive in the global market. This also offers an opportunity to increase employment.

Investment in R&D work can take advantage of the longstanding Slovenian tradition in hydraulic machinery and expand development to other renewable-energy sources: solar energy, wind energy and geothermal energy.

Gregor Pucelj
DELO

Celje District Heating Plant
Heat and Power from Waste

Celje District Heating Plant, which is much more than the name suggests, has been operating in the Celje industrial zone since the end of 2008 (on a trial basis for the first year). It is a state-of-the-art facility for the thermal treatment of municipal waste and sewage sludge from waste-water treatment facilities, which, in the process of energy utilisation, produces enough hot water to provide heating for approximately 3000 homes, and 2 MW of electricity, which is enough for around 800 households. KIV of Vransko carried out design and implementation of the fully automated and computer-controlled process.

We were shown Celje District Heating Plant by Dr Filip Kokalj (left) and Dr Alen Šarlah (right) of KIV Vransko, and Associate Professor Dr Niko Samec (centre) of the Faculty of Mechanical Engineering of the University of Maribor.

The Regional Waste Management Centre project began in Celje six years ago. It is being carried out in two phases, with the first phase – involving construction of a dump, a collection centre and a sorting centre for municipal waste – already having been completed. The second phase involves construction of a facility for mechanical biological treatment of municipal waste (built on the same location as the landfill) and the thermal treatment (incineration) plant – mentioned in the introduction – for pre-processed municipal waste residue and cogeneration of heat and power; this facility is close to the town in order to minimise heat losses caused by transmission. This is the first project of its kind in Slovenia. The whole project of comprehensive regional waste management was presented in Brussels as an example of good practice. With individual additional solutions adapted to the specific needs of individual environments, it could also set an example for others.

Energy rich waste and waste sewage sludge

Only what is known as the light fraction of waste – comprising plastic, paper, cardboard, textiles and wood with a high energy value of on average around 16 MJ/kg, more than most coals – is transferred from the mechanical biological municipal waste treatment facility to Celje District Heating Plant. According to Associate Professor Dr Niko Samec, Dean of the Faculty of Mechanical Engineering at the University of Maribor, who played an important role in the preliminary design of the comprehensive regional concept, and who, together with colleagues, has played an active part in implementing the project, this case involves a fundamentally different technological solution from classic incinerators, the aim of which was purely to eliminate waste. In this instance, however, the process is enhanced with useful energy obtained from combustion. In line with the EU Directive, the Regional Waste Management Centre in Celje is designed so as to involve both material utilisation – where secondary raw materials and biowaste are separated – and energy utilisation of municipal waste. The latter is only used for waste with a high calorific value that cannot otherwise be economically exploited.
As explained by Dr Filip Kokalj of KIV Vransko, who also works at the Faculty

of Mechanical Engineering in Maribor, and who was the project manager responsible for the design and implementation of Celje District Heating Plant, another important environmental dimension of the project is that, in addition to light fractions of municipal waste, it can also incinerate sewage sludge from the Celje municipal waste treatment facility. When the district heating plant starts full operation – scheduled for the autumn – it will, in one year, process 20,000 tonnes of light fraction municipal waste and 5,000 tonnes of sewage sludge from the treatment facility.

It must be stressed that Celje District Heating Plant is primarily an environmental facility. This means that, when waste is processed as the primary task, the generation of heat and power is in the background. This also means that replacing fuel from waste with another energy vector would be uneconomic, as the price of heat and power thus generated would be excessive. "There is no similar facility in the world that cuts the cost of waste management, but it is the only way that we can comply with the EU Directives that from July this year prohibit any form of dumping of energy-rich and biologically active waste," said Dr Kokalj.

Celje killed two birds with one stone through this solution. The plant will eliminate waste problems and generate 2 MW of electricity and 15 MW of heat (the electricity-heat ratio could also be different). As this will not satisfy all demand, the new Celje District Heating Plant also includes – separate from the incinerator – two gas-fired water boilers with a combined power of 27 MW. They will primarily be used as so-called peak boilers, to cover spikes in demand or during sustained severe cold weather.

Although the incinerator has a two-stage combustion system that practically prevents the survival of any type of organic compound and produces fewer dust particles, it will every year produce 500-800 tonnes of fly ash and residues from flue gas cleaning – these are collected and processed as hazardous waste.

View of Celje District Heating Plant

Trial operations showed that a steady flow of waste, or refuse-derived fuel, is important for the district heating plant. Consideration is therefore already being given to the construction of an additional storage facility in the mechanical biological municipal waste treatment plant, to hold a few weeks stock of pre-prepared waste fractions, so that the incinerator and district heating plant do not run out should there be some delay in their preparation.

Far below emissions limits

What is or will be the environmental impact, and what are the atmospheric emissions? As Dr Kokalj explains, Celje District Heating Plant is an energy facility with certain environmental emissions. Since in practice the combustion efficiency of waste varies by as much as 25%, managing the process in such a facility is particularly challenging, and so the dimensions of certain units, such as the furnace and the waste treatment centre, have to be larger. This is fundamentally different from and more demanding than ordinary district heating and thermal power plants, which have more or less identical and stable fuels with fixed combustion efficiency.

"The environmental parameters we are achieving during trial operation show that emissions from Celje District Heating Plant are far below emissions limits. Under Slovenian law, we measure 14 parameters in flue gases, and these measurements are publicly available on the Internet as half-hourly and daily average values. There is thus permanent monitoring and operational transparency," says Dr Kokalj. "We recognise that in Celje, and particularly in the industrial zone, the environment has been heavily polluted for years, and so every additional impact becomes that much more of a burden. It is important to emphasise that the minimal emissions from Celje District Heating Plant represent substantially less of a burden than the previous municipal waste management method (almost entirely landfill). Unsorted and unprocessed municipal waste with high levels of biodegradable waste produced greenhouse gases, particu-

KIV of Vransko is active in the European market, primarily through the development of systems for waste and biomass incineration. It has sold or built a series of devices in Central Europe (Slovenia, Germany, Italy, Slovakia, Netherlands, Croatia), as well as some smaller units in Russia. Recently, the company has turned its attention to the Spanish, French and British markets. Internet address: http://www.kiv.si/

Main part of the incinerator – It contains two incineration chambers and a steam-generating boiler[1].

Monitoring area – All processes are followed and monitored on computer screens.

larly methane, which are much more problematic than carbon dioxide. Celje District Heating Plan will thus have an indisputable positive environmental effect," stressed Dr Samec.

What will remain after thermal treatment of 25,000 tonnes of waste? Approximately 15% will be ash on the grate of the incinerator, a non-hazardous waste that will be returned to the landfill. Although the incinerator has a two-stage incineration system that renders practically impossible the survival of any sort of organic compound and that produces fewer dust particles, every year it will generate 500-800 tonnes of fly ash and residues from flue gas cleaning; cleaning these will require additives – from activated carbon dust and sodium bicarbonate to coke and ammonia solution water. This is hazardous waste, which is treated as such and exported to disused salt mines in Germany.

Transparency

"At the same time, we recognise the seriousness of the problems caused by organic substances such as dioxins and furans, which are undoubtedly carcinogenic and mutagenic substances. Due to incineration in two chambers at high temperatures of around 900 degrees Celsius, the introduction of air and suitable mixing, organic substances in our facility are completely incinerated in the furnace, while subsequent treatment systems, including adsorber with coke and activated carbon coal dust ensure that they are fully removed and serve as a backup in case something undesirable is released from the combustion chambers. It is only at this stage that the flue gases are released to the chimney, where, as mentioned, 14 parameters are measured. At the end of the year, all of this data is provided to an authorised institution, which produces an operating report that, together with a series of other reports on the environmental impact of the district heating plant and on the quantities and composition of thermally processed waste, are submitted for review to the Environmental Agency of the Republic of Slovenia," explained Dr Kokalj.

That this is a state-of-the-art facility is further shown by the fact that its operation need only be monitored by two people per shift, an engineer and an electrician, although in fact they only monitor how the computers control the whole process; the district heating plant will of course operate 24 hours a day, and so we will need three shifts, as well as a facility manager, a graduate ecologist and a few ancillary workers, making a total of 15 employees. We can truly be proud that the technology and engineering (which is the largest added value) used – from the design of the furnace and boiler to cleaning flue gases of Celje District Heating Plant – are the result of domestic knowledge from KIV of Vransko and the Faculty of Mechanical Engineering in Maribor which, since the early 1990s, have been cooperating in the development of such technologies; construction also involved CM Celje for building works and Mollier Celje, which supplied electrical power equipment.

For the Celje District Heating Plant project as a whole, it is important to note that the investor, the Municipality of Celje, managed to obtain 70% grant funding from EU cohesion funds, providing an excellent example of the opportunities for using EU money for development projects in Slovenia.

Fuel – Light fraction of waste, prepared for incineration, is almost free of the odour typical of most municipal waste.

A web-based information system for supporting management and control of autonomous manufacturing work systems on the shop-floor level is introduced.

Web-based Monitoring and Control in Discrete Manufacturing

Peter Butala, Borut Rihtaršič and Alojzij Sluga

Manufacturing complex investment goods, such as energy and industrial equipment, is a demanding process mainly due to the uniqueness of customers' requirements. Each customer order is a project requiring extensive engineering and completion works, such as design, development, fabrication, assembly, shipping, erection and installation at the construction site, plus testing and commissioning of a complex product. It requires highly motivated and competent personnel, adequate organisation, and the effective management and control of each value-adding and supportive process, and the project as a whole. The management and control functions must perform adequate planning of activities and resources, creation of adequate information and material flows and assurance of required materials, tools, and information at the right time at the right place at minimum cost, along with monitoring of individual processes, operations and projects.

The key issue for management and control is assurance of reliable and current information for decision-making when and where required. This can be assured only with online monitoring of events and states on the shop-floor and with adequate information systems for supporting decision-making.

This realisation inspired the development of the concept of a workshop-information system, as shown in Figure 1. The concept is implemented as an information system named LIMES (Litostroj Manufacturing Execution System). LIMES has been put into operation in several workshops of the company Litostroj Power.

Figure 2 reveals the architecture of the LIMES system, which is based on a modular structure and enables integration with other relevant information systems in a company. These are the Enterprise Resource Planning (ERP) system on one side and a Supervisory Control and Data Acquisition (SCADA) system on the other side. The PDA (Production Data Acquisition) terminal shown in Figure 2 is a touch-screen display located on the shop floor close to work systems. It serves to display information to operators (work orders in a queue, work instructions, drawings, etc.) and manual input of data related to characteristic events, such as the start of work on a work order, machine breakdown, missing information, etc., which occur during manufacturing operations. Factory Ling is a commercial SCADA application, which

The authors, A. Sluga, P. Butala and B. Rihtaršič, received the Gold Award for Innovation of the Slovene Chamber of Commerce and Industry / Regional Chamber Ljubljana in 2004.

Peter Butala, University of Ljubljana, Faculty of Mechanical Engineering

Borut Rihtaršič, Litostroj Power, Ljubljana

Alojzij Sluga, University of Ljubljana, Faculty of Mechanical Engineering

periodically (at two-minute intervals) collects data from sensors on machine tools. The sensors indicate the states of the machine tools in terms of on/off (1/0). These data are not meaningful by themselves but, linked with data about events, they provide a clear picture of the situation in a workshop. A database server manages a database which gathers all collected data. The LIMES data model is implemented in the relational database Oracle, which manages the data.

The software logic is based on the concept of rules, which enable monitoring of several tasks performed concurrently on the same work system. This corresponds to the nature of work in the workshop. The logic is based on a sequence of events and activities. The logic is coded in a web application and runs on an application server.

The application logic of the LIMES system is implemented on the MS Internet Information Server (IIS), which runs on the Microsoft platform .NET. It is based on object-oriented technology and enables advanced programming of applications. The presentation logic is implemented as a classic web application. The interface, which enables access to LIMES, is a standard web browser, such as MS Internet Explorer or Mozilla Firefox. This allows access to workshop information over the company's intranet from anywhere, at any time, without any special software tools. Access is secured with the virtual private network (VPN) technology. The LIMES modular structure enables trouble-free adaptation and upgrading of the system. At the same time, the system is open and stable.

Since the implementation of the system in Litostroj, the workshop data have been collected and analysed on-line and systematically. All actors involved

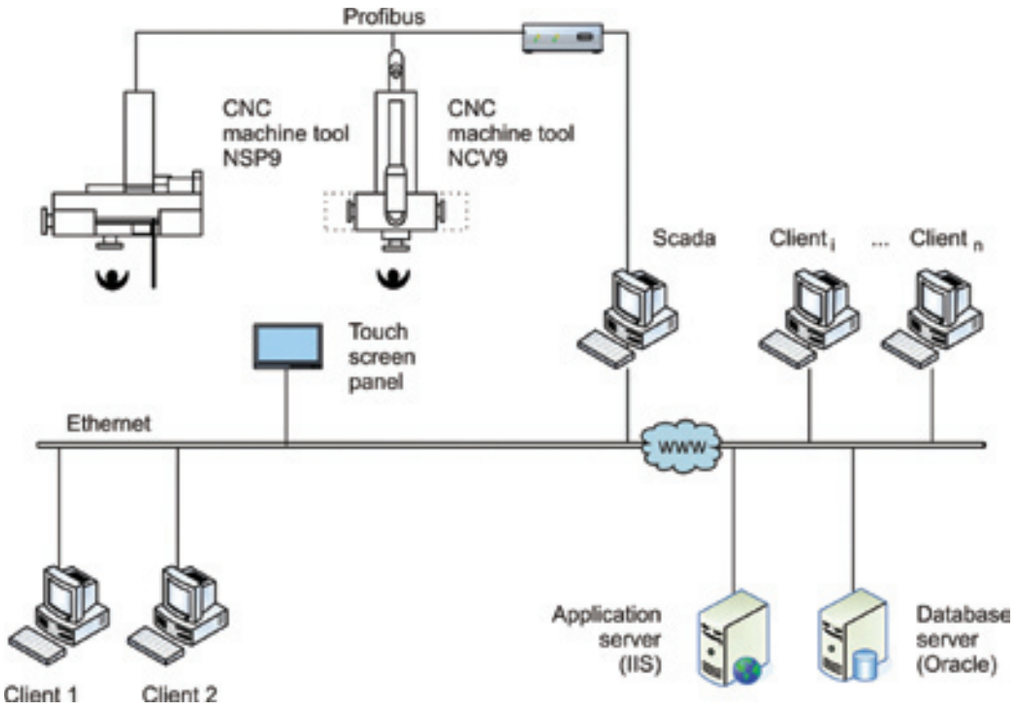


Figure 2: Architecture of the manufacturing execution system LIMES

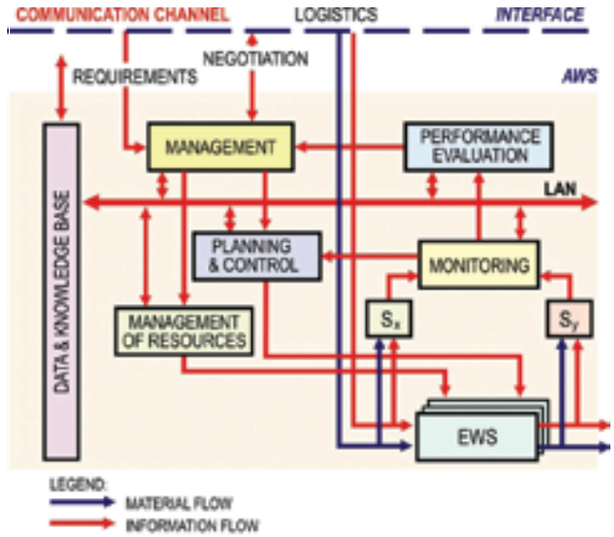


Figure 1: Structure of the manufacturing-execution system LIMES

Professor Jože Duhovnik, Dean

University of Ljubljana, Faculty of Mechanical Engineering

Professor Jože Duhovnik, Dean: *"At our faculty we create and disseminate new knowledge with a strong emphasis on innovative solutions for industry. The presented innovations come from the area of manufacturing systems. Both of them originate from latest findings in the field of new manufacturing structures and are realised with advanced web technologies."*

in the manufacturing processes on various decision levels are now able to access the system online. Results and experiences are being regularly reported to senior management.
Let us now explain some functionalities of the LIMES system. Figure 3 shows the starting page of the system, which gives a clear picture of the current situation in the Litostroj workshops at first glance. Red and green boxes represent work systems – green those in operation and red those currently inactive. To investigate what is happening on a particular work system, information can be retrieved by clicking on its icon. Figure 4 displays a detailed graphical view on the 24-hour timeline of the current day. Four graphs are displayed, which provide insight into operational details, (1) continuous monitoring of operations from the SCADA system (0/1), (2) operator presence (logon, logout), (3) events related to work in process (start and end of work on a work order, interruption, break), and (4) interruption of operations.

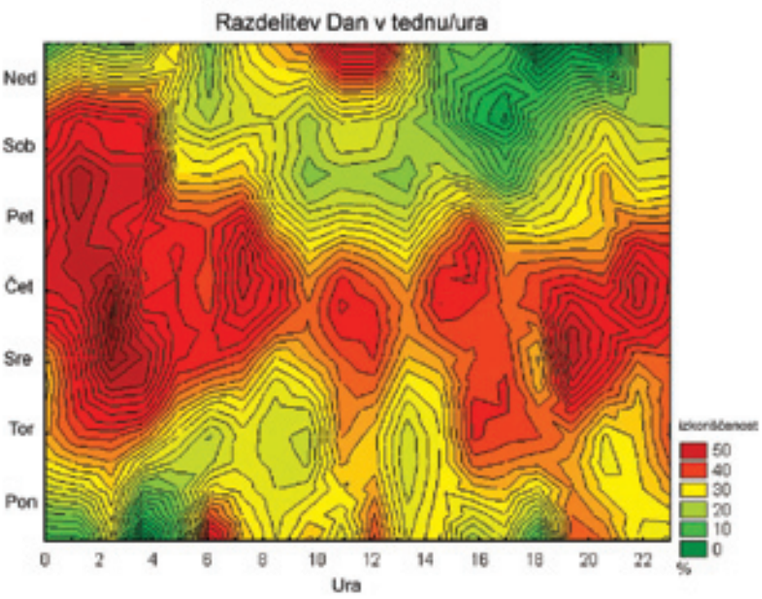
The LIMES web application allows rapid analysis of activities and interruptions according to the ISO 9001 standard. It facilitates automatic generation of standard periodic reports and calculation of performance indicators, such as productivity, overall equipment efficiency, equipment availability, completion rate of work-in-process, etc. All these information provide online feedback for decision-making, control and management of a workshop on all decision levels. Figure 5 depicts an example of such an analysis, which provides powerful aggregate information on average work-system utilisation over

Figure 3: Web-based monitoring of production

Figure 4: Daily activities of a work system

Figure 5: Example of performance evaluation – 3D contour plot of the average utilisation of the work system HM1, $\bar{U}_{j,k}$, m=27, n=48.

a longer period of time. Based on this information, the user can notice when the system is not sufficiently efficient, discover the causes for inefficiencies and provide adequate measures for improvement.
A special messaging service has also been developed. Certain events trigger automatic messages for different services (e.g. a machine-tool breakdown triggers an e-mail and SMS to the maintenance department) and the management level.
LIMES is based on advanced concepts, open architecture and advanced information and communication technologies. A local database, which is regularly synchronised with the ERP system, assures decision-making autonomy. As a web application, it supports workshop visibility from inside, as well as from outside.
It should be noted that the system has been well received by management, workshop personnel and by other users whose work depends on shop-floor information. Due to the reliability and timeliness of production data, their visibility and interpretability, management decisions on all levels are improved.
These gratifying results are (1) access to relevant data from everywhere at anytime, (2) significantly increased visibility of the workshops and thus timely transparency of operations, (3) increased reliability of schedules and delivery, (4) increased operational performance in terms of lead-time reduction (40%), increased utilisation of resources (25%), increased reactiveness in case of malfunctions (50%), (5) significant reduction of administration and paperless information flow, (6) better understanding of operational problems and their causes and consequently more efficient management and organisation of work, e.g. maintenance, and (7) better distribution of management between the company and project management, and the autonomous management of the workshops. The last is recognised by the key personnel of the company as a significant contribution.



Experimental Autonomous Manufacturing Cell

Peter Butala, Ivan Vengust and Alojzij Sluga

In recent years, researchers have intensively searched for new manufacturing concepts to create foundations for next-generation manufacturing systems. Among possible solutions for these challenges are networked, adaptive and reconfigurable manufacturing systems. These new manufacturing structures open several questions about their design, development, operations and other life-cycle phases, which must be answered in current research and development.

Researchers predominantly use simulation techniques and virtual environments for the exploitation of new ideas and concepts. But for in-depth research and development of new concepts, methods and tools for next-generation manufacturing systems this is not enough. An adequate infrastructure is needed, which would enable verification of research hypotheses in a more or less real environment. Only on this basis can acceptable and verified solutions be developed, for implementation in industry without excessive risks. The experimental autonomous manufacturing cell LAKOS EAC presented in this contribution is a building block of a network of manufacturing cells being developed within the European project I*PROMS. It is the first instance of the development of such research infrastructure on the global scale.

Networked manufacturing systems are composed of autonomous building blocks, which communicate, cooperate, collaborate and also compete among each other. From the theoretical point of view, networked manufacturing systems are within the category of complex adaptive systems (CAS). A CAS is a system built up from autonomous and rather simple entities, which interact among themselves. The interaction also takes place between the autonomous entities and the environment. The interaction induces the phenomenon of self-organisation, which may result in global order in the CAS.

To implement the CAS concept in the manufacturing domain, adequate autonomous entities or building blocks must be defined. Logically, the building blocks could be enterprises, which are autonomous by definition. But, as established in previous research, enterprises are complex hierarchical structures and as such, due to numerous communication channels and decision levels, are unresponsive, cannot be adapted and are intolerant of control. Therefore, they are not suitable as the building blocks of next-generation manufacturing systems.

Due to this conclusion, the concept of Autonomous Work Systems (AWS) was developed [Butala and Sluga, 2006]. To fit into the CAS concept, AWS is defined as a rather simple structure with rounded technological functionality and corresponding management functionality. The technological functionality is build around

The authors received the Recognition for Selected Innovation at the 2nd Slovene Innovation Forum, 2007, and the Silver Innovation Award of the Slovene Chamber of Commerce and Industry / Regional Chamber Ljubljana, 2009

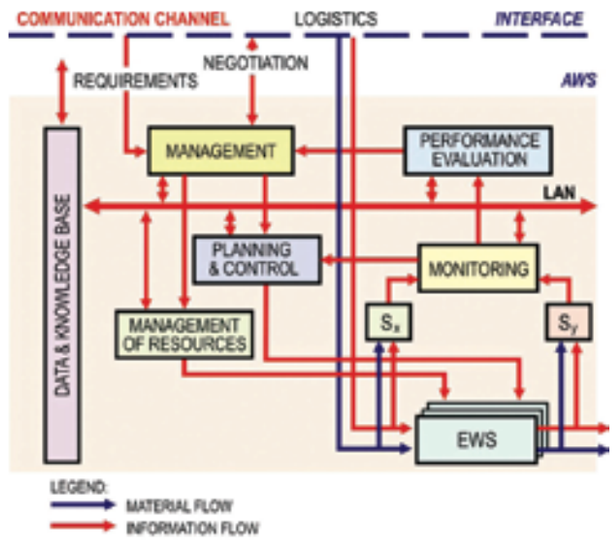


Figure 1: Structure of an autonomous work system

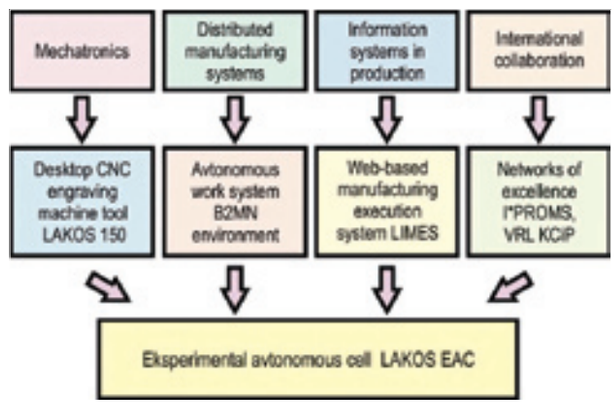


Figure 2: The development of the LAKOS EAC system [Editor's note – correct spelling in figure: Autonomous . Experimental autonomous cell]

so-called elementary work systems, which are, according to the definition [Peklenik, 1985], composed of a process (e.g. turning), a process implementation device (e.g. a lathe) and a human subject (e.g. a machine operator). The management functionality encompasses management and control of work operations, and communication and interaction with other systems. The structure of an AWS is shown in Figure 1. The elements of management and control, elementary work systems, and elements for surveillance and monitoring can be seen. The elements are connected in two control loops. The inner loop enables online real-time control of operations and is composed of (1) scheduling and control, which allocates tasks to elementary work systems and controls their (2) sensors and monitoring in the feedback.

The outer control loop enables performance-based control. Operational performance is evaluated form the measured monitoring data over a longer period of time. On this basis, deviations from expected performance and inefficiencies can be identified. This serves for preparation of adequate correction and improvement measures. The concept is described in more detail in previous research [Butala and Sluga, 2006].

The autonomous experimental cell LAKOS EAC is an example of implementation of the AWS concept. The objective here is to establish a comprehensive pilot platform for conducting experiments on new manufacturing concepts and for investigation of new technologies in a real, semi-industrial environment.

AEC is a synthesis of results of the research efforts of the laboratory LAKOS at the University of Ljubljana, Faculty of Mechanical Engineering in several complementary domains, as shown in Figure 2.

Within the mechatronic field, the laboratory developed and completed a prototype of a desktop computer-controlled (CNC) machine tool, the LAKOS 150. The objective of this work was to develop a modern educational instrument for mechatronics and automation, firstly to satisfy the laboratory's own needs in education and later to offer it to schools at different educational levels. The machine tool enables milling, drilling and engraving of workpieces made of light materials. Figure 3 shows an example of 3D milling on the LAKOS 150 machine.

The second important field of research in the Lab is the area of distributed,

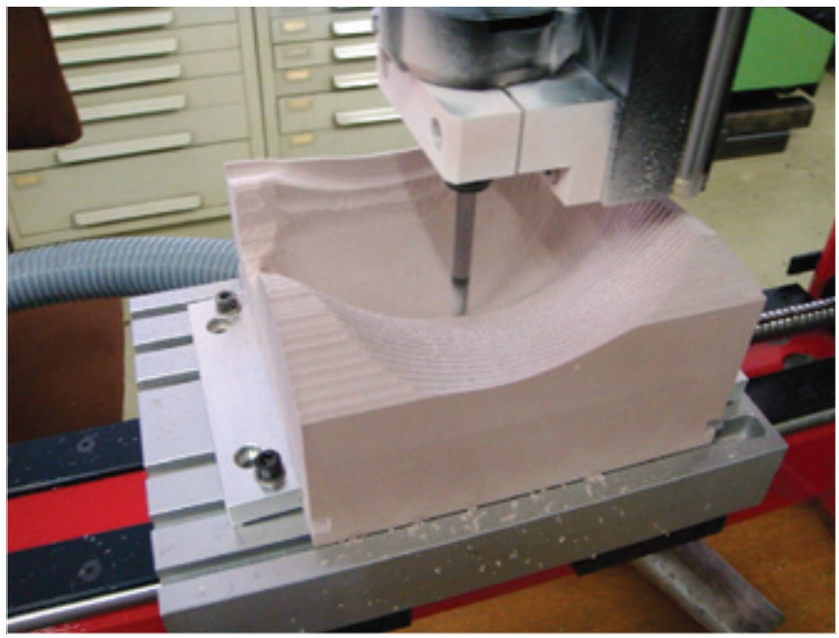


Figure 3: Example of 3D milling on the LAKOS 150 desktop CNC machine tool

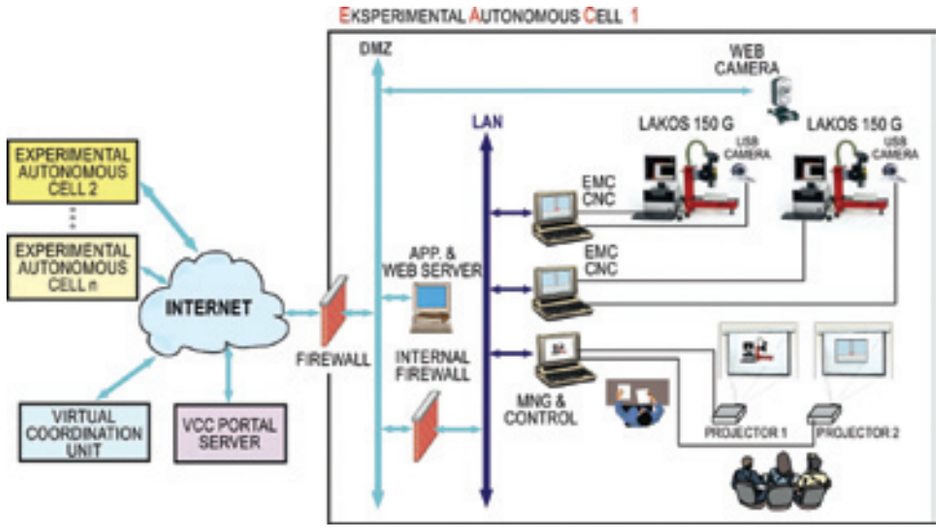


Figure 4: Architecture of the autonomous manufacturing cell LAKOS EAC and its connection to the web.

adaptive and networked manufacturing systems. Within this framework, the generic concept of autonomous work systems, which is the underlying concept of EAC, was developed. The concept of a network mechanism called B2MN (business-to-manufacturing-network) was also

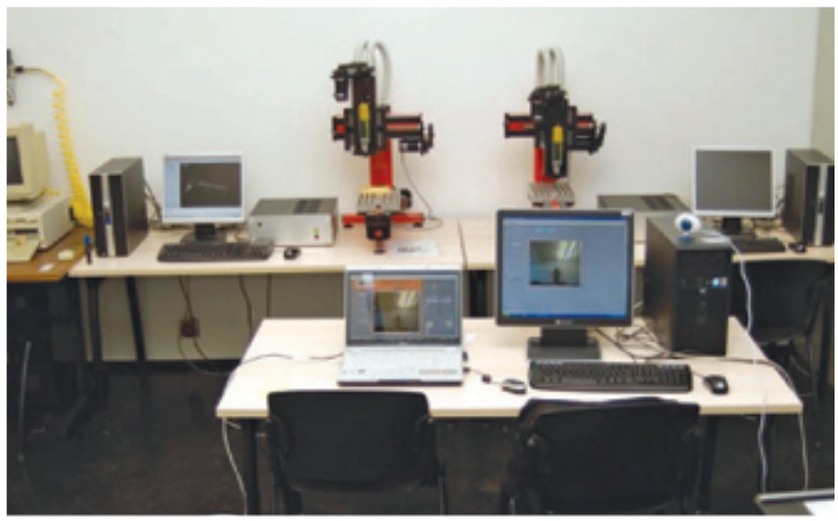


Figure 6: The UMS cell at the University of Minho [Putnik et al., 2008].

developed. This concept is being investigated in the network of EACs.

The third field of interest, the research and development of information systems in production, has also contributed to the development of EAC. Within this context, the web-based workshop information system LIMES, which was developed to support the AWS concept and is being implemented in industry, must be mentioned.

It should be pointed out that without the rich international cooperation and collaboration of the laboratory within several international groupings, this innovation would not come to existence. Particularly important was participation in the European network of Excellence VRL KCiP and close collaboration with the Portuguese University of Mingo, which was involved in another European network of excellence I*PROMS, which helped to trigger and fertilise the idea.

Now let us have a closer look at LAKOS EAC. The cell is composed of two CNC desktop machines, a logistics system and a management/control system. It is equipped with elements of ambient intelligence for pervasive and ubiquitous e-services. Among other functions, these elements enable wireless communication among system elements, identification of the object with RFID technology and web cameras for surveillance and monitoring of processes. The cell control is based on the principles of self-organisation and implements agent technology. The cell is connected to the web. Cell operations can be observed and controlled over the web in a ubiquitous manner. Figure 4 reveals the architecture of the EAC and its openness to the world. Several cells in different geographic locations form a manufacturing network.

These features allow EAC to become a real environment for advanced research in the field of autonomous work systems and a space for implementation of state-of-the-art information and communication technologies in the manufacturing environment.

On this basis, an experimental manufacturing cell is being developed in the laboratory under the working title "the desktop factory", which will serve as a platform for conducting experiments within the Eureka project E!4277 UES "Ubiquitous oriented embedded systems for globally distributed factories of manufacturing enterprises".

Within the European network e excellence I*PROMS, an experimental platform for investigating ubiquitous manufacturing systems called "UMS – Ubiquitous Manufacturing System demonstrator", is being developed. The partners are four universities, the University of Minho from Portugal, the University of Warwick from the United Kingdom, Dublin City University from Ireland and Sakarya University from Turkey. The University of Ljubljana is an associate partner in the project. The UMS demonstrator connects the network shown in Figure 5.

Figure 5: UMS demonstrator network.

Figure 7: Implementation of virtual presence in the UMS demonstrator [Putnik et al., 2008].

The UMS demonstrator is based on UMS cells that are similar to EACs. The heart of the cell is two LAKOS 150 machine tools, which enable basic machining processes to be performed in the cell. Figure 6 shows the UMS cell installed at the University of Minho.

The UMS cell is connected to the web. Operations can be observed over web cameras, which enable realisation of the "virtual presence" concept [Putnik et al., 2008]. The concept virtually eliminates geographic distance and integrates the platform. Figure 7 displays the implementation of the virtual presence concept in the USM demonstrator.

The UMS demonstrator also allows for surveillance and monitoring of processes on the LAKOS 150 machine tool as well as remote control of the machine. This functionality was developed specifically to enable its integration in such platforms.

The key feature of the demonstrator is that real machining processes can be performed on all machines integrated. This feature distinguishes the demonstrator from the simulation environments in which this kind of research experiment is currently performed.

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[2] [Peklenik, 1995] Peklenik J., 1995, Complexity in Manufacturing Systems, CIRP Journal of Mfg. Syst., 24/1:17–25.

[3] [Putnik et al., 2008] Putnik G.D., Raja V., Szecsi T., Oztemel E., Kubat C., Sluga A., Butala P., 2008, I*PROMS experimental platform and test-bed for research and development of the Ubiquitous Manufacturing Systems (UMS). 6th CIRP International Conference on Intelligent Computation in Manufacturing Engineering, CIRP ICME'08, Naples, Italy, p. 6.

Helios: Innovations and New Technologies are our Challenge

Our R&D strategy is driven by ecological standards, new application developments and innovative solutions.

Peter Venturini and Bogdan Znoj

Helios Group is one of the largest producers of paints, lacquers and synthetic resins in Central Europe, with more than 30 companies in 14 countries. Its sales portfolio contains a very wide assortment of products and trademarks, and includes paints for decorative use (wall and facade paints, enamels for wood and metal, parquet lacquers), road-marking paints, paints for the metal and wood industry, automotive paints and car-refinishing paints. Helios Group also manufactures solvent- and water-based synthetic resins such as alkyds, acrylics and polyesters.

Helios Group covers more than 15 different markets in the European Union, Eastern Europe, South East Europe and Russia. These markets have different traditions, environmental legislation and economic standards but important changes can be observed in the last ten years on all of these markets. Helios is aware of this situation and has responded in part by reorganising R&D on different levels.

Dr Peter Venturini, Assistant Chairman of the Management Board for Research and Development:

"The R&D department can answer tomorrow's business challenges only with open co-operation on innovation"

Business and organisational challenges

Customers' expectations, environmental legislation and new scientific discoveries are drivers towards more R&D as a high strategic priority for Helios. Helios employs more than 200 staff in R&D departments including more than 100 employees with a bachelor or higher degree. To provide superior quality in innovative and environmentally friendly products and technologies, a high level of knowledge, modern equipment and good collaboration with partners in the academic and industrial sector are essential.

In recent years, changes have been introduced in organisation of R&D, forming teams with a critical mass. A central R&D department was also established to provide future novel products and technologies to provide higher added value of products. The innovation process in central R&D, as well as other R&D departments, is open in Helios to partners in research institutes and universities. Researchers from Helios are working together with partners on several research projects. A good example is in the national centres of excellence, where breakthrough innovations are expected.

Why are new technologies so important?

The last decade was highly intensive in R&D for the European paint companies because of the VOC directive and REACH legislation. The VOC directive is focused on the reduction of volatile organic solvents in paints. This can be achieved with polymers with a higher solid content and comparable application viscosity or through development of water-based coatings with polymer disper-

sions. In the field of wall paints, the water-based technology is dominant, whereas the high-solid approach is still a majority choice in the metal industry.

The REACH legislation will have an important influence on the development of new paints in the next decade. REACH will prohibit the use of several substances that are potentially toxic. They will have to be replaced by more acceptable substances. The replacement of those substances and technologies requires a profound knowledge and understanding of materials interac-

Uroš Slavinec, President of the Management board of Helios Group:

"We must focus more attention on our researchers because we need modified and new products to fulfil European Union directives.'"

Self-healing paints

Damaged automotive clear coat after abrasion exposure.

Healed automotive clear coat after "reflow effect".

The most important function of paint is protection of the substrate from weather and abrasion conditions. Abrasion and other mechanical impacts are usually the reason for a damaged paint film on a metal substrate. The result is corrosion and destruction of the material. The challenge for paint engineers was to improve the paint film to be more resistant to impacts. One solution was the self-healing effect whereby the paint can heal scratches under certain conditions. Helios studied clear coats for car refinishing with different glass-transition temperature. A clear coat has successfully been developed that has improved scratch resistance and shows the self-healing effect at temperatures above the glass-transition temperature of polymers. The phenomena is also called the "reflow effect".

Automotive clearcoat can be damaged by abrasion exposure during the car washing process.

tion on the molecular level. Here, we expect that Helios will have an important competitive advantage.

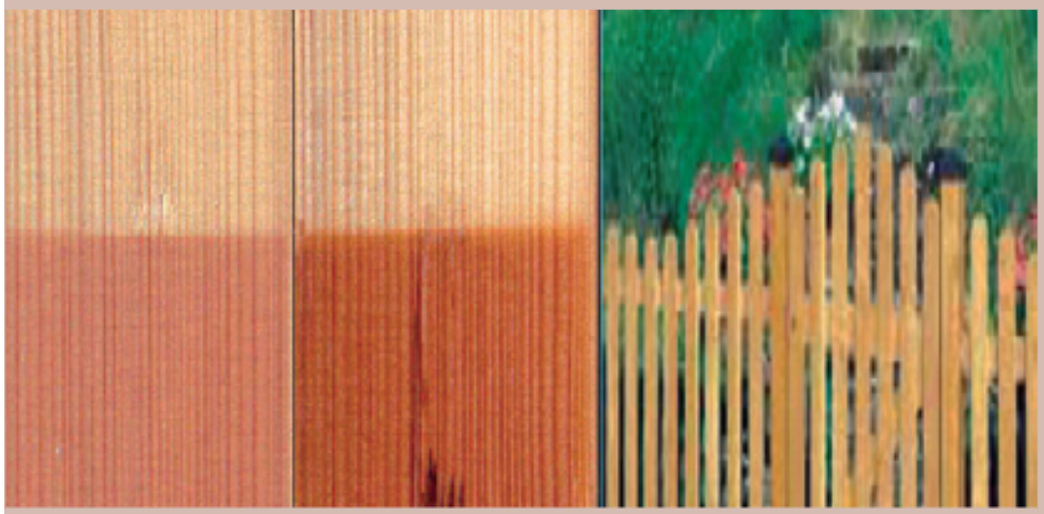
Dr Bogdan Znoj, central R&D department of Helios Group:
"Development of new technologies requires good understanding of materials interaction on the molecular level."

What about innovative ideas that are not connected with environmental requirements?

Recent scientific discoveries and technological progress, including nanotechnology, provide an excellent basis for the development of synthetic resins and coatings with significantly improved properties, valuable for both individual customers and industrial users of our coatings. Helios has developed several functional coatings using nanomaterials and nanotechnology. These innovations were focused on mechanical and optical properties important to users,

"Self-cleaning" and UV-absorbing paints

Both of these applications use nano-scale TiO_2 particles with an average particle diameter of less than 100 nm. The difference is in the crystal form of TiO_2. The "self-cleaning" application is at the stage before commercialisation, but UV-absorbing technology has been commercialised for more than two years as a UV-absorbing paint for wood protection. The "self-cleaning" effect



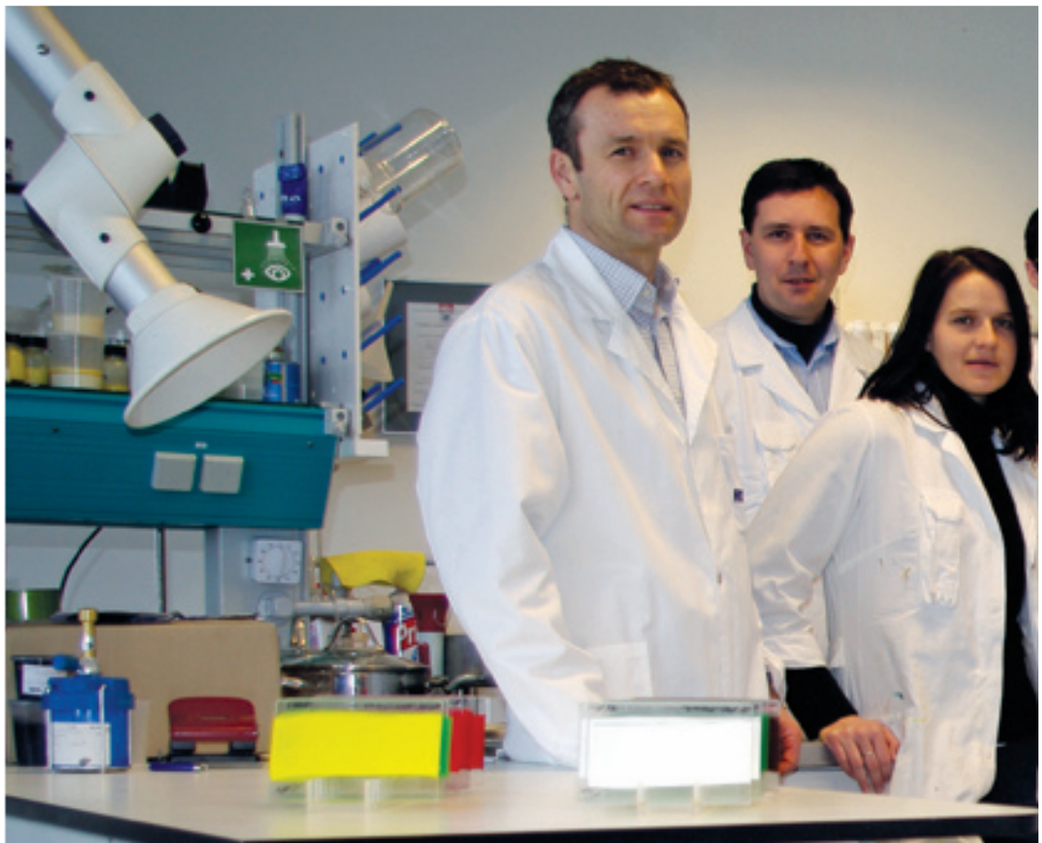
UV absorptive paint with nanoscale TiO_2 in rutile chrystal form

Classic paint.

UV-absorbing paint for outside protection of wood.

is the result of the photocatalytic activity of nano-scale TiO_2 in anatase crystalline form, which reacts in façade paint to organic dirtiness. The result of this process is CO_2 and water, and clean façade paint. UV-absorbing paint contains nano-scale TiO_2 in rutile crystal form, which absorbs UV light, preventing degradation of the polymer resin in paint. The biggest challenge for researchers was to disperse the nanoparticles efficiently in paints with different composition, to avoid agglomeration of particles.

Researchers in the central R&D department of Helios Group



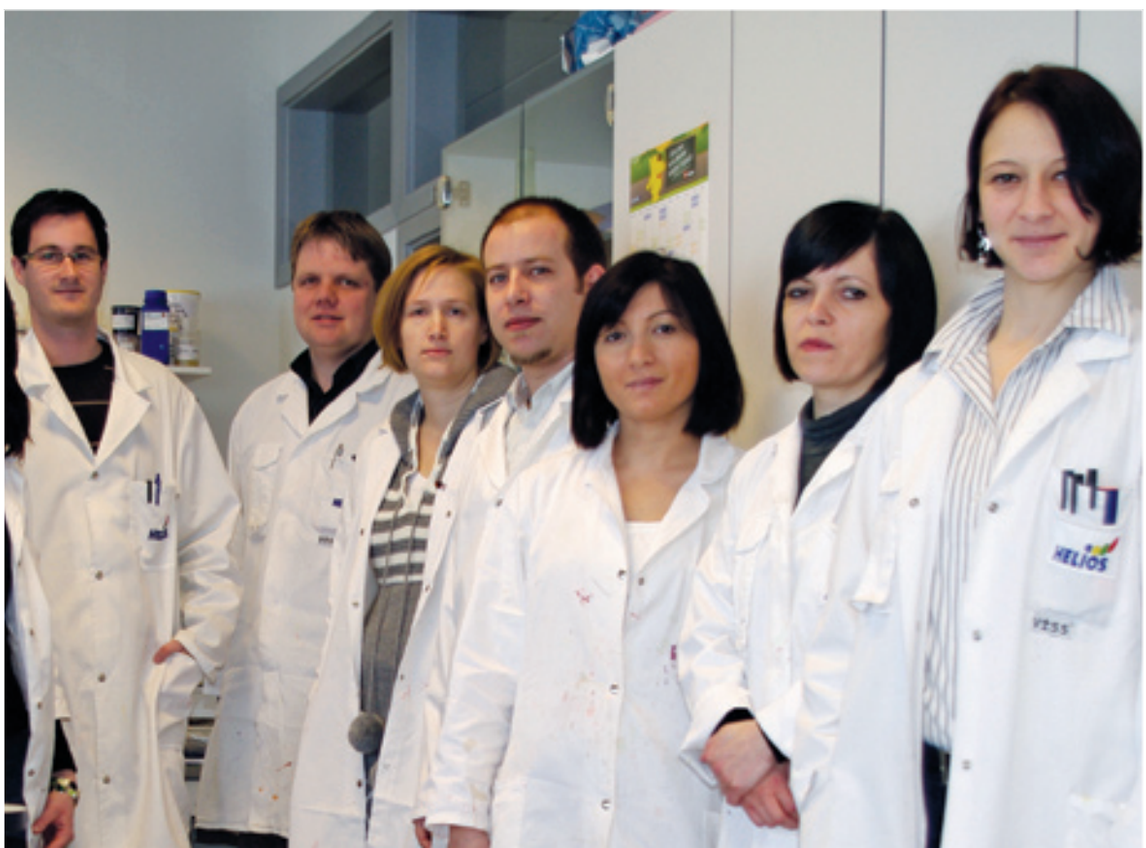
Highly effective classic solar system with spectrally selective paint.

New highly effective solar block system with spectrally selective paint.

Spectrally Selective Paints

Almost 50% of the fossil fuels burnt in Europe are used for heating. As the EU's Renewable Energy target sets a mandatory goal of 20% for the proportion of renewable energy in gross domestic consumption by 2020[1], it is clear that the majority of newly installed renewable energy sources should be in the area of heating. The obvious answer to this challenge comes in the form of solar thermal power. A 10-fold increase of the current market for solar-thermal installations is forecast. Still, new technically and financially affordable solutions are needed to fulfil the goals set.
Helios Group's solution to the demands of the solar-thermal market are spectrally selective paint coatings for solar absorbers. The development programme was initiated in the 1980s through co-operation with Slovenian research institutes. The current range of spectrally selective coatings marketed under the brand name "Suncolor" is based on two technologies: thickness-sensitive spectrally selective (TSSS) paint coatings and thickness-insensitive spectrally selective (TISS) paint coatings. The technology was developed for highly effective solar systems used in different applications. A hard and highly heat-resistant spectrally selective coating that may find its way into planned solar-thermal power plants in the Sahara is also being developed.

1 Commission Communication of 10 January 2007: "Renewable Energy Road Map. Renewable energies in the 21st century: building a more sustainable future".
2 Solar Heating and Cooling for a Sustainable Energy Future in Europe, Revised Version, European Solar Thermal Technology Platform, Brussels, 2009.



such as self-healing, self-cleaning, spectral selectivity, UV-absorbing, exhalation of different substances, '"self-marking"', as well as new technologies such as PGSS, UV and LED technology. Improvements have also been made in known technologies like water- and solvent-based technologies or e-coat applications. Several innovations have already been commercialised and will be presented closely.

How do we see future trends and our position in the paint market?

The future will provide many challenges in the coating industry. For traditional customers, who need paint for aesthetics and protection of substrates, such as wood and metal, important paint modifications will be prepared due to environmental legislation. Industrial customers will, besides such environmental needs, also have higher expectations on paint that will allow faster industrial lines and improved properties. The third priority will be new applications, which can be expected in the area of smart coatings. Smart coatings will have sensing capability and will respond to outside stimulus in a similar way to examples in nature such as nonporous bioactive smart coatings, super hydrophobic coatings, intelligent conducting polymers for corrosion-protection coatings, antifouling coatings, etc.
The paint industry can offer many innovative technological solutions for lower energy consumption. The future success of any coating company will to a large extend depend on its R&D capability providing high-quality and environmentally sustainable solutions.

A remarkable New Generation

Vesna Petkovšek

Gorenje is one of the leading global home-appliance manufacturers with 60 years of tradition. The company's high-quality products, manufactured at plants in Slovenia Gorenje, the Czech Republic, and Serbia, have a 4% share of the European market. Of total sales, 90% are exports, with the majority (80%) sold under the manufacturer's own brands Gorenje, Mora, Atag, Pelgrim, Etna, Körting and Sidex.

Vesna Petkovšek

Throughout the 60 years of its history, Gorenje has been constantly growing to develop into an international corporation that today includes 88 companies, of which 66 are headquartered abroad. In addition to household appliances, we have complemented our offer with our own programme of kitchen and bathroom furnishings, as well as a wide range of products for the home. In past years, the company has been strengthening its activities in the segments of environmental protection, energy management, and services, where we are employing our skills and forty years of experience in environmental protection.

With its products and services, subsidiaries and nearly 10,500 employees, Gorenje is currently present in 70 countries on all continents, but mostly in Europe, which remains its key target market.

Gorenje is continuously investing in the development of new innovative environmentally and user-friendly appliances distinctive for their design; technological processes are also constantly being updated to make the production process more productive, accurate, and employee-friendly.

Along with its focus on the mass segments of the home appliance market, where the struggle for market share is fiercest, Gorenje is also devoted to finding new market niches, new approaches to consumers, and to providing new consumer experiences with its home appliances. As part of this approach, the Gorenje Simplicity line, introduced last year, charted out a new course in the development of home appliances, relieving users of tedious decision making and allowing them to take more pleasure in what they really enjoy. Simplicity is Gorenje's response to contemporary trends in the way we live, and to the desire – or the decision – to live a simpler life. Apart from technological perfection, these appliances also provide simple and logical control using a single dial. Other major projects of recent years include a new generation of cooking appliances which now represents 70% of this segment, and three key product groups: 60 cm wide cookers (ranges), built-in ovens, and cooking hobs.

The innovative new generation of cooking appliances

Cooking appliances are Gorenje's flagship segment among the major appliances. The new generation introduced entirely new technological and functional features, environmentally and user-friendly solutions, and fully revamped attractive design while, very importantly, keeping manufacturecosts at the same level as before. A total of EUR 20 million was invested into the new generation of cooking appliances. At Gorenje, four key segments of cooking appliances are manufactured: 50 and 60 cm wide cookers (ranges), built-in ovens, and cooking hobs. Every two to three years, each line undergoes major revision; alternatively, entirely new generations are developed. A redesign of such an extensive part of production as in this project is rare in the industry, as it is very exacting and

Franjo Bobinac, President and CEO:

"The home-appliance industry is mature and saturated, as concentration of both manufacturing and distribution is ever increasing, and it appears that this trend will extend into the future. Competition is fierce, and includes powerful Western global manufacturers with years of tradition, challenged by the aggressive entry of low-cost Asian providers. Furthermore, our industry is severely hit by the recent economic crisis. Gorenje is responding to all these challenges by optimising business processes, by extending our offer to various segments and all price ranges to retain, or indeed increase, our market shares, as well as by entering new markets. And above all by developing products and services that are based on research and global trends in consumer lifestyle and perceived as correct for our customers: those that will ease household tasks, improve functionality, offer simpler control and improved service. Therefore, we must think outside the box and remain highly committed to investment into R&D, which remains very important – perhaps even more so during harsh economic times."

Boštjan Pečnik, Executive Director of Development:

"R&D activities in the Gorenje Group are focused on the development of environmentally friendly products offering innovative technological solutions and excellent design to make the day-to-day life of users simpler. We are aware that satisfied customers are the best marketing for our products, so seek to learn about our customers' habits and needs, to properly address them with our products. Our research projects are focused on the search for technological solutions that will reduce power consumption, on development of environmentally friendly materials and technologies, and on making our appliances easy to use.

Gorenje's core development resources for major appliances are concentrated at the parent company plant in Velenje. This is a valuable asset to us, with a concentration of both knowledge and lab equipment. We have four major development departments for cooking, washing and drying, refrigeration, and electronics. Two additional and quite powerful development centres, specialising predominantly in development of cooking technology, are located at Atag in the Netherlands and at Mora in the Czech Republic. In addition to our own facilities, we also work closely with many universities and research institutes in Slovenia and abroad. We are aware that R&D of new products and services are a key generator of competitiveness and will therefore continue to up our investments in this area."

Prof. Dr Iztok Žun, Head of Laboratory for Fluid Dynamics and Thermodynamics at the Faculty of Mechanical Engineering, University of Ljubljana:

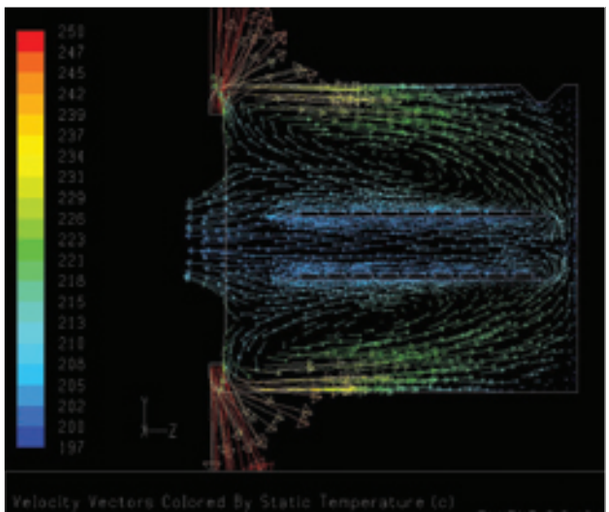
"A tremendous increase in computing power and available software tools has enabled experts to build a knowledge base for new industrial products from first principles in engineering physics. Complex processes can be efficiently simulated and boundary conditions can be altered to obtain optimal energy use and the best possible performance. One such example is the development of the Gorenje new-generation oven, in which heat is spread evenly throughout the oven cavity, enabling simultaneous cooking on multiple levels. The research programme group of the Laboratory for Fluid Dynamics and Thermodynamics at the Faculty of Mechanical Engineering of the University of Ljubljana made a significant contribution with a numerical simulation of the thermal and velocity field over a phase boundary, working hand in hand with the Gorenje R&D engineers to optimise oven geometry (the shape and cover of the oven fan). The numerical simulation was carried out in several steps. A discrete 3D model was designed using approx. 500,000 control volumes. The solution of the transport equations enabled the study of pressure, velocity and temperature fields under a steady state and transient conditions."

Mitja Rudolf, Head of Cooking-Appliance Development:

"Along with simple operation, development of the oven was focused on functionality, power efficiency, and excellent cooking conditions.
Despite developing an oven with a large useful volume (60 litres for multifunctional and 65 litres for conventional ovens), our innovative solutions in the oven cavity area allowed us to design the entire appliance range to an A energy class rating.

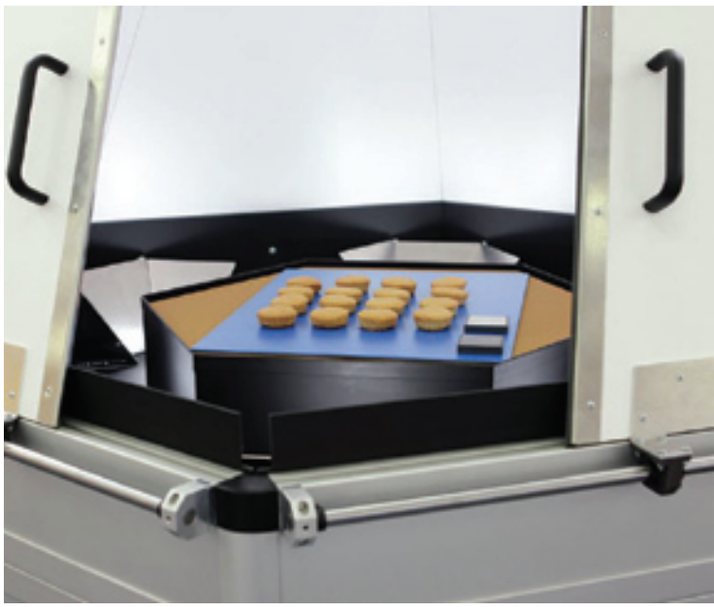
The new construction of the oven cavity also improved the rigidity of the oven casing, despite its lesser mass. Indeed, the lesser mass of the oven cavity, combined with other technological solutions, reduces power consumption and allows rapid oven preheating (reaching 200 °C in less than 6 minutes).
Optimum cooking conditions were a particular priority in the design, with distribution of thermal and velocity field in the multifunctional oven being of paramount importance. Working with the experts of the Faculty of Engineering at the University of Ljubljana, we optimised the thermal and velocity conditions in a way that leads to excellent cooking conditions for single- or multi-level cooking. The oven thus boasts 83% of effective grilling surface, which is among the best ratings in the industry.

Employing numerical simulations, we managed to reduce development time and costs for producing concept prototypes. Based on simulation results, we improved the oven cavity and reached optimum thermal-velocity conditions.



Innovative solutions employed in the new Gorenje built-in ovens, coupled with well-thought-out heater placement, paved the way for superior results. The rounded lines of side walls and the arched ceiling (inspired by wood-fired ovens) results in the most effective distribution of hot air throughout the oven, thus cooking all the food evenly throughout the oven cavity.

The electronic module is a revolutionary innovation introduced in the new generation of Gorenje cookers and built-in ovens featuring touch-screen operation. Numerous preset programmes allow automatic selection of the optimum combination of heaters, temperature, and cooking time. Furthermore, all parameters can still be set or adjusted manually. User settings can be saved and easily retrieved from the memory upon subsequent use of the oven.



"The Space Capsule" or device for standardised measurement of cookie browning. This sophisticated piece of equipment is used at Gorenje to determine how evenly food is cooked in the oven. Based on the colour and consistency of food, the quality of the cooking process is rated and any requirements for further changes in heater power or construction adjustments are determined.

challenging. However, Gorenje was able to manage the process to great benefit as standardisation of components led to a reduction in production complexity.

A general trend in the home-appliance market is a notable growth of demand for built-in appliances. The new generation therefore also expands the range of products in this segment. Another apparent trend is consumers' desire to save time and energy while cooking; responding to this trend, Gorenje has improved the power efficiency of its products and optimised preheating times. Oven capacity has also been increased (to 60 litres for multifunctional models and 65 litres for ovens without a fan) while keeping the outside dimensions unchanged, thus allowing users to cook more food at a time. Needless to say, oven volume by itself is not enough; it is the ways in which it can be used that matter. In new Gorenje ovens, grid and baking sheet rails have been pushed further to the side to increase the cavity volume and to allow the use of larger baking sheets, giving them an edge over competing models. A revised oven-cavity shape allows excellent circulation of air throughout the entire cavity and thus leads to more uniform cooking results. All models of the new generation have an "A" energy class rating.

Five patents for five original solutions

Working with other departments within the company, Gorenje development teams developed and implemented completely fresh technological designs and user solutions for the new products. These have been patent protected as they are unique in the industry. The patent applications include **inclination of the oven-cavity ceiling**; inspired by the shape of the traditional

wood-fired ovens, this solution leads to excellent baking results. Another original solution is the **upper heater** installed in two height levels aligned with the inclined ceiling. This solution was arrived at through computer simulations of baking, which proved that a heater layout of this kind is highly beneficial. Another patented solution deals with the heat radiated into the oven's environment. Constant pressure on the furniture industry to employ more environmentally friendly materials in kitchen cupboards has led to the use of adhesives that are more sensitive to humidity and heat. It is therefore important that kitchen appliances alleviate such effects. Gorenje experts have addressed this issue by developing an improved oven-cooling system that allows cool air to circulate between the oven and adjacent cabinets.

Another cooling-related patented solution is the **door cooling system**. Since our competitors have patented a number of solutions related to this aspect, it was all the more challenging to find a new, original solution. The Gorenje development team managed to direct the cooler air from the front wall in such a way that it also cools the oven door.

Sensor-controlled electronic timers are another patented solution, allowing users a simple choice of functions and settings directly on illuminated symbols; these symbols also display the operation status of the appliance.

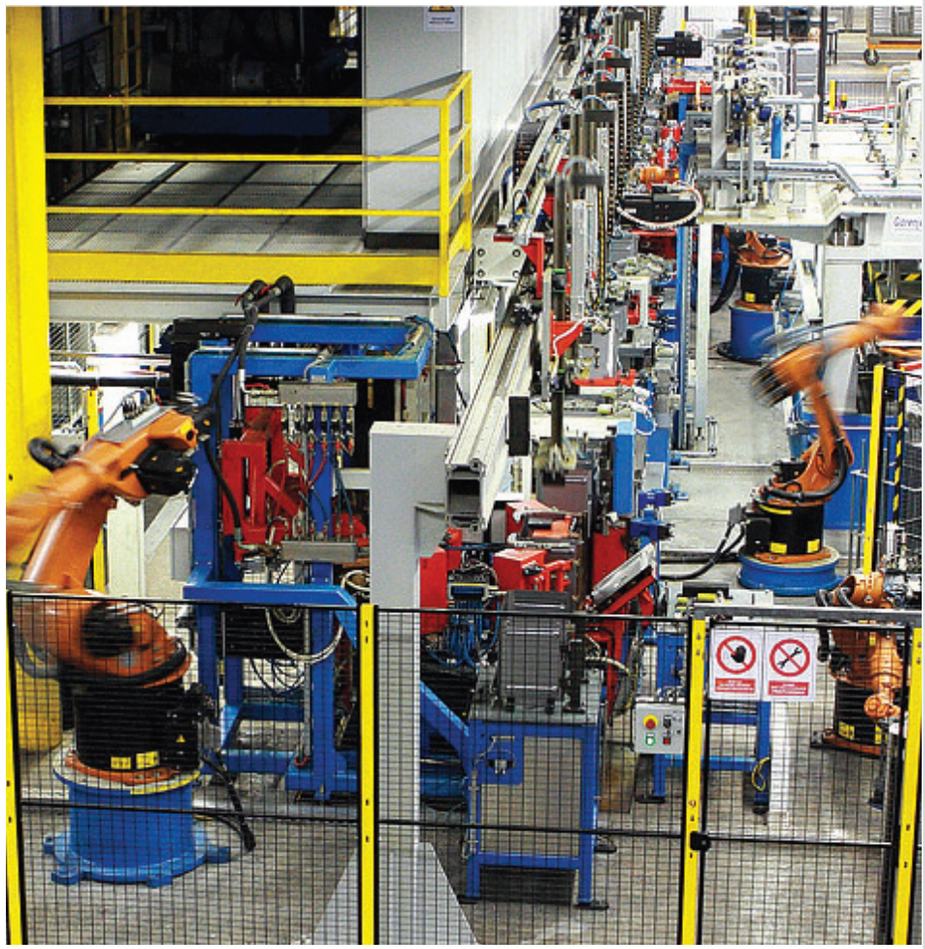
The **appearance of the appliance** was also registered. A notable trend regarding home appliance design in the recent years is that home appliances blend with adjacent furniture. On the one hand, Gorenje offers appliances to accommodate this trend; on the other hand, customers who seek something different are offered more distinctive designs focused on excellent ergonomics, clarity and intelligibility, and user-friendly operation.

Nineteen different appliance models were designed, in two collections. Line A, later dubbed "Pure", is "neutral" and will suit any kitchen; line B, later called "Allure", is more dynamic and sets itself apart from other equipment. The new design also reduced production complexity as the electronic timers on the appliances were standardised and the number of dials and buttons reduced. Operation using as few buttons as possible is also in tune with users' preference for simpler maintenance and cleaning.

With the new generation, Gorenje has prepared a comprehensive range of kitchen appliances with harmonised design. Along with cookers (ranges), built-in ovens and cooking hobs, it also includes kitchen hoods (or fans), steam and microwave ovens, dishwashers, and coffee machines. The design of the free-standing refrigerator door-handle links all pieces of kitchen equipment into a harmonious aesthetic whole.

New automated oven assembly line

To meet the requirements of the new generation of cooking appliances, Gorenje's subsidiary, Gorenje Indop, produced a new oven assembly line. The line is fully automated, which means that only fork-lift truck operators delivering material, and the engineer controlling the entire line are required for its operation. The new line is highly productive, as it is 15% faster than the previous one. Even more importantly, it provides higher quality and production reliability.



Unique electronic control of the new appliances

Electronics plays a major part in the development of kitchen appliances, as electronic control has become a pronounced trend in the market. To properly equip the new generation of products, Gorenje experts developed a concept quite novel among cooking-appliance manufacturers. To date, electronic control used backlit graphical symbols displayed in the centre of the display while actual control relies on touching the sensors next to those symbols. In the new appliances, the appliance functions or settings are selected simply by touching the illuminated symbol, which is considerably simpler and more user-friendly.

To develop the new electronic model, Gorenje experts used a touch-sensitive film, another innovation in this segment. They also combined the display and function selection sensor/key into a single symbol, employing capacitive sensors that operate through glass. A conducting layer was added to the front panel film in such way that it does not interfere with its basic properties or restrict design possibilities – on the contrary, it opens up new possibilities. The conducting layer of the film was then connected to the control electronics, which thus responds to touch. Electronic modules can be integrated into both glass and metal versions of the appliance front panel.

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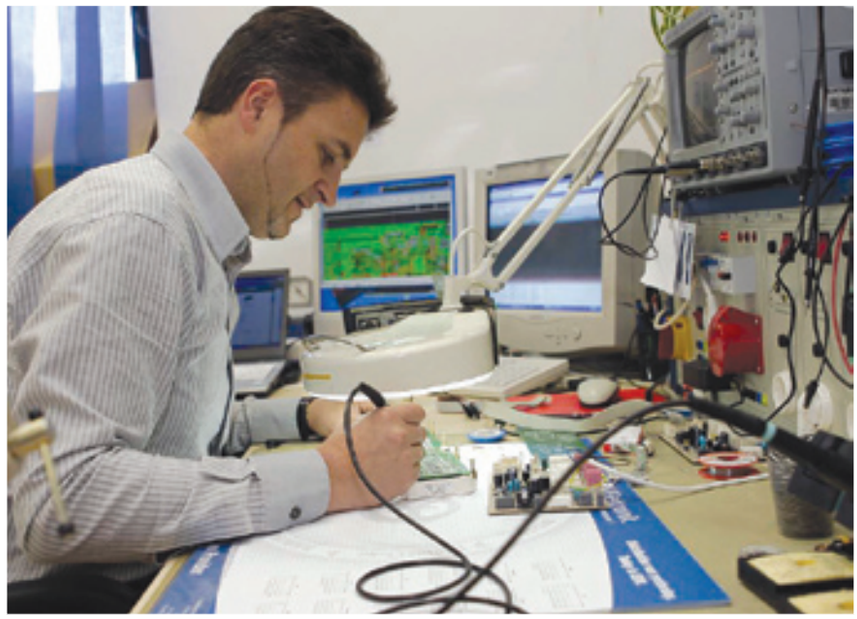


Gorenje Simplicity line is the response to contemporary trends in the way we live, and to the desire – or the decision – to live a simpler life. Apart from technological perfection, these appliances also provide simple and logical control using a single dial.

Transformation of manufacturing technology

Taking place in the background of the development of each new generation of appliances are extensive technological processes and preparations that may be beyond the imagination of the final user choosing among different appliance models. Gorenje's kitchen-appliance manufacturing plant was largely revised, re-equipped and updated, and some entirely new manufacturing lines were set up on the shop floor. New technological acquisitions included two presses, of 1,200 and 500 kN, used to manufacture components of built-in ovens and kitchen ranges.

Gorenje's subsidiary, the machine-building company Gorenje Indop, manufactured the new assembly line by complying with the highest standards of ergonomics. The conveyor-belt system was remodelled into a tact system to allow the workers to stand in place while working, rather than constantly move along the belt. Moreover, hanging transporters for delivering oven casings from the enamel-coating plant to the assembly line were replaced with a new system that conveys the half-built product directly to the work post on the assembly line.

One hundred new tools were implemented in the kitchen-appliance manufacturing plants. These and other improvements have resulted in considerable progress in terms of productivity and flexibility.

CoE

Centers of Excellence

- The CoE NIN
- The CoE NOT
- The CoE CIPKeBiP
- The CoE PoliMaT
- The CoE NAMASTE
- The CoE EN-FIST

Also present at the introductory meetings of Centres of Excellence are prominent scientists from abroad, invited speakers, and the Minister of Higher Education, Science and Technology, Gregor Golobič. The introductory meeting of the CIPKEBIP Centre of Excellence was also attended by Robert Huber, winner of the 1988 Nobel Prize in Chemistry.

From the left: Walter Keller (University of Graz, Austria), Jan Dohnalek (Academy of Sciences of the Czech Republic), Silvia Onesti (Elettra Synchrotron, Italy), David Stuart (Wellcome Trust Centre for Human Genetics, Oxford, UK), Wayne Hendrickson (Columbia University, NY, USA), Gregor Golobic, the Minister of Higher Education, Science and Technology, Robert Huber, winner of the Noble Prize for Chemistry (Max-Planck Institute of Biochemistry, Germany), Dušan Turk, Project Coordinator and Hartmud Luecke (UC Irvine, California, USA).

Eight were accepted for funding

Jana Kolar

In order to facilitate scientific breakthroughs in an increasingly globalised world, its countries and regions need to focus more than ever on fostering research excellence and competencies in fields known as "smart specialisations". With this in mind, the Ministry of Higher Education, Science and Technology has recently allocated 77 million euros to eight Centres of Excellence (CO), characterised by scientific excellence and innovative industry. Considered by many to be a rather daring move, especially in these times of economic crisis when funds are scarce, these Centres were mainly financed by the European Regional Development Fund (ERDF).

Dr Jana Kolar, Director General, Science Directorate, Ministry of Higher Education, Science and Tecnology.

The first tentative steps towards smart specialisation were taken in 2006, when the government decided to allocate approximately 15 million euros to ten Centres of Excellence for a period of three years (http://www.centriodl.si). Evaluation undertaken on the economic viability of the Centres established that they are, despite some shortcomings, a valuable instrument in strengthening cooperation between the public and industrial sectors. (http://www.centriodl.si/index.php?option=com_docman&task=doc_view&gid=2&tmpl=component&format=raw&Itemid=28&lang=sl).

The study concluded that the Centres of Excellence are one of the few instruments that promote an interdisciplinary approach to research and development and are, therefore, well-suited to the needs of the economy where disciplines tend not to be mutually exclusive. They are an instrument that determines R&D priorities in an innovative fashion and support the concentration of resources in areas of technology that are vital in ensuring the competitiveness of the economy. As they also contribute to the efficient flow of knowledge and applications into products and services, a continuation of the measures was proposed.

Positive feedback encouraged the government to publish a call for eight new Centres of Excellence in 2009. From over sixty applications submitted, eight were accepted for funding. These covered the disciplines of nanoscience, biosensors, instrumentation and process control, chemistry and protein biology, low-carbon technologies, non-metallic materials, plastic materials, space science and nuclear magnetic resonance studies. The annual expenditure for the research and development of enterprises in the Centres of Excellence is 270 million euros per annum, which is the same amount the Government of Slovenia allocated for R&D purposes in 2009.

The consortia were requested to form a new legal entity, managed by the partners. These new entities employ 420 researchers, with every fourth researcher being employed from an industrial partner organisation. While it is still too early to assess the effectiveness of the new Centres, it is expected that they will lead to the development of new products, processes and services, as well as new business models, better knowledge transfer and improved management of intellectual property rights.

We hope that the new Centres are filled with creativity, innovation and cooperation during the course of the next four years.


Photo: BOBO.

Borut Pahor, Prime Minister of Slovenia:

"Centres of excellence are a decisive move towards concentrating knowledge and technological development in key areas. At the same time, they are an outstanding example of linking knowledge, science and economies, since they have brought together almost all the institutions and companies that are providing the basis for development in Slovenia. It is especially important in times of crisis for the government to take decisive action to support those fields in which we are capable of excellence on the world scale. This is the path that will place us right up there with the most advanced players. Through the centres of excellence we have indicated that the current government is pursuing this objective, and also intends to do so through future measures."

Professor Marija Kosec, Director of CoE: NAMASTE: "Research and subsequent discovery, and the eventual product development are, by definition, very distant from each other, and aptly described as a 'Valley of Death'. Nevertheless, every country seeks to bridge these gaps and bring together communities that can perform both these activities. Centres of Excellence, a concept unique to Slovenia, are such an example. The requirements in the call for proposal are clear. The consortium must consist of representatives from both research institutions and industry. The projects within the centres force researchers from both communities to conduct their research together. This is the best way to start listening to each other and, finally, to trust each other."

Dr Otmar Zorn, Director of Iskra Zaščite: 'Centres of Excellence are a positive example of a practice where companies with their development potentials link up with the scientific research sphere. Their aim is to bring about shifts or leaps in the development of new technologies, materials and new discoveries which, in the long term, will ensure the success of the entities involved, particularly industries, and of the country as a whole.'

Setting up a technological infrastructure platform for the competitive development of N&N in Slovenia in the next decade

CoE in Nanoscience and Nanotechnology – Nanocenter

Dragan Mihailović, Martina Knavs

The Center of Excellence in Nanoscience and Nanotechnology – Nanocenter is organised as a consortium of 15 partners, of which 4 are academic and 11 are industry partners. The work is co-ordinated by the Jožef Stefan institute. The consortium includes all prominent groups working on nanotechnology from two of the largest and most prestigious research institutions and the University of Ljubljana. The companies within in the consortium are leading companies that are looking towards nanotechnology as a means of increasing the added value of their products and moving into knowledge-based operations. The consortium includes the majority of nanoscience and nanotechnology (N&N) researchers in Slovenia.

Members of the consortium have published the results of their work in leading publications with significant scientific impact, such as Science, Nature, Nano Letters and Nanotechnology.

The companies in the partnership are amongst the most successful in Slovenia in terms of added value and R&D expenditure.

Prof. Dr Dragan Mihailović

The extremely rapid worldwide progress in N&N crucially relies on new technologies for the creation, study and control of matter on the scale of atoms and molecules. Slovenian researchers have a proven track record in N&N on the world stage, placing Slovenia in a very competitive position in terms of scientific output in the field of nanotechnologies at the beginning of this decade. The present project is designed to address the challenge imposed by the extremely rapid development of N&N by joining together the efforts of all leading research groups and industry leaders in the field into a national consortium with the single goal of setting up technological infrastructure platform for the competitive development of N&N in Slovenia in the next decade. The project focuses on setting up state-of-the-art synthesis, processing ("nanofacturing") and characterisation facilities on an internationally competitive level, which will enable a diverse range of cutting-edge R&D projects.

The key advantages of the programme and consortium are: (i) the excellent starting position for Slovenian nano-scientists on a competitive level among highly developed nations (ii) the inclusion of all leading teams in the country working on nanotechnology from academia, government research labs and leading industries, (iii) a programme of high-tech infrastructure development, which facilitates a qualitative increase in competitiveness and

Martina Knavs

Gorenje d.d.

Boštjan Pečnik, Executive Director of Development:

”Gorenje is among the leading manufacturers of home appliances in Europe. To rank among the best in this field, in Europe and worldwide, in terms of development of technologies and products, the company has established a top-class R&D network both within the company and in co-operation with research and educational institutions in Slovenia and abroad. This highly organised and sizeable interdisciplinary unit of researchers is capable of competing on an equal footing in international consortia and in European R&D projects.

Gorenje is an innovative company. The R&D unit combines researchers and development engineers from all fields of the Gorenje Group’s technological-development portfolio and is registered with the Government of the Republic of Slovenia. It is the hub of R&D of products and technologies, and functions as a generator of the knowledge required for development. This knowledge is accumulated and developed in partnership with domestic and foreign institutions. The ultimate goal of the innovation process at Gorenje is the development of new products that will not require a push strategy in the market (i.e. will not require extensive marketing activities to support sales) but will rather allow a pull strategy (i.e. there will be ample demand because of the product itself). Gorenje pursues this goal by implementing R&D projects financed within the group or sometimes partly subsidised by the Slovenian Government or the European Union. Most of these projects, regardless of the sources of financing, include independent (i.e. external to the group) domestic or foreign partners, companies, and R&D or knowledge institutions.

Gorenje will be a leading partner in the nanomaterials in consumer goods research topic.

Boštjan Pečnik, Executive Director of Development

Cinkarna Celje d. d.

Vladimir Vrečko MSc:

“As one of the largest companies in the Slovenian chemical industry, Cinkarna Celje is very interested in research into new materials, processing technologies and their applications. With this knowledge and experience, we are also a potentially significant industry partner, “ said Vladimir Vrečko.

QUARK: *“And so you joined the Nanocenter?”*

Vladimir Vrečko: “Yes, Cinkarna Celje sincerely believes in this organisational model as an example of efficient and productive co-operation between educational and research institutions and the industrial sphere. The second reason is the research program of the Nanocenter, which is in our opinion of great potential, and may serve as a key opportunity to gain high-tech knowledge that could be used in developing some new and highly competitive industrial products.”

Vladimir Vrečko MSc

QUARK: *“What do you expect from the collective work in the Nanocenter until 2013 and beyond?”*

Vladimir Vrečko: “In general, we expect deep and extensive collaboration not only with the National Institute of Chemistry, but also with the other research and industrial partners within the partnership. As a producer of titanium dioxide, Cinkarna Celje is interested in R&D activities for applications connected with the use of ultrafine titanium dioxide. Our main aim is investigation of mechanisms and properties that would favour use of titanium dioxide in novel applications.”

a long-term multiplier effect (iv) the establishment of systematic facility support, which ensures transparent and easy access to young academic researchers from diverse fields and researchers from industry. Systematic education in the area of N&N within the project will ensure long-term collaboration, state-of-the-art science and technology, and continuing knowledge-exchange on the highest level, extending well beyond 2013.

The topics covered by the Nanocenter cover infrastructure facilities for:

1) synthesis of new materials using a variety of different techniques;
2) processing facilities such as nanolithography and nanofabrication facilities;
3) advanced characterisation facilities, including safety.

All facilities are to be fully supported by experts and facility management staff, to allow efficient access to both members of the consortium and outside users from industry.

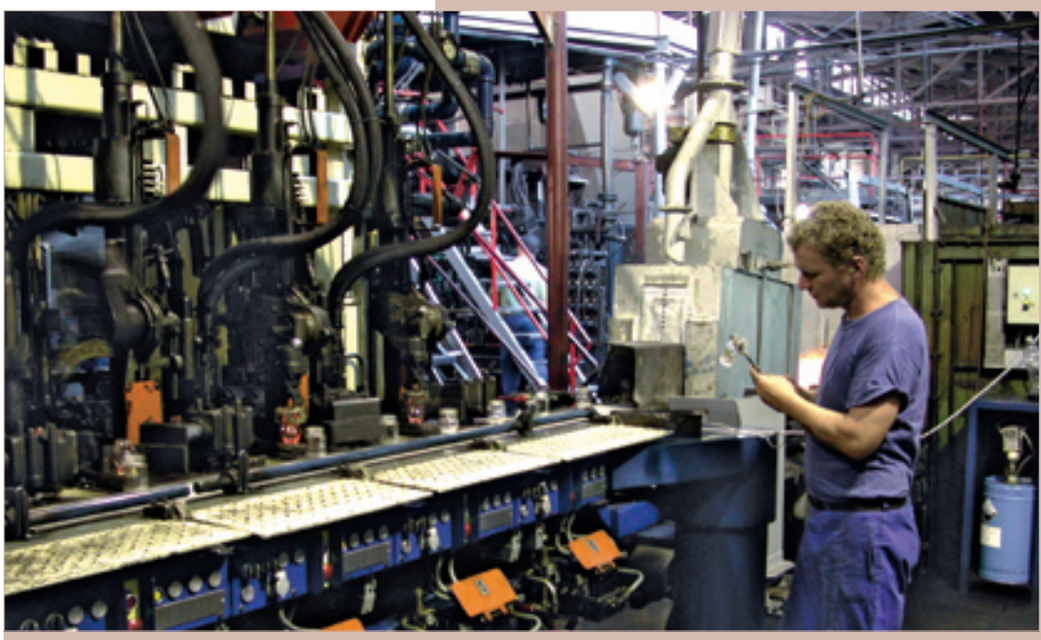
1.) The synthesis of new nanomaterials is especially important for industrial applications. New materials, discovered and synthesised within the centre, can be the basis of new technologies and products, offering the members a competitive advantage. Synthesis of nanomaterials requires modern equipment, such as molecular-beam epitaxy, pulsed-laser deposition and high-pressure and temperature synthesis methods. The centre encompasses different synthesis projects from

ETA Cerkno d.d.

is a producer of heating and control components for the white-goods industry. The main lines of production are cast-iron hotplates, radiant heaters for glass/ceramic cooking systems, electric tubular heating elements and capillary thermostats. In our area of production, we are, as a member of the EGO Group, an important (and in some cases the biggest) production and development organisation in Europe and the world. Our expertise in materials plays an important role in development, quality assurance, and technology. Material characterisation on the nano scale is therefore also important for us. One special area of interest is characterisation of the insulation materials used in our products. For these reasons, ETA Cerkno joined the Center of Excellence in Nanosciences and Nanotechnology – Nanocenter. Besides characterisation, we also see opportunities for developing nano-materials for electro-insulation and humid sealing.

Steklarne Hrastnik d.d.

Anton Novak, Head of Development: " Steklarna Hrastnik has more than 150 years of experience and know-how in the field of glass manufacturing. Processing and finishing are synonymous with high flexibility in production, craftsmanship and up-to-date technology.
In the production of industrial glass for lighting, tableware and special container glass, different technologies, including automatic blowing, automatic pressing, semi-automatic production and mouth blowing are used.



IS machine for glass container production

The vision of the company is to become the leading European company in the field, with high business capability, resources and a high-quality production environment for glass production.
The business goals of the company are to anticipate our customers' wishes and fulfil their ever-increasing demands in terms of design, quality, precision and serviceability. For this reason, we are constantly searching for and developing new ideas, methods, materials, tools and techniques. We believe that the Nanocenter project is an excellent opportunity in this field.

molecular nanotechnology to nanocomposites and nanostructures, coatings and films. Important research areas and directions in nanomaterials from the point of view of applications within the CE are:

- Nanomaterials for electronics, informatics and communications;
- Thin films and nanostructures, for electronics and sensors;
- Nanomaterials for biochemistry and medical applications;
- Nanomaterials for energy, batteries, fuel cells and photovoltaics;

Thin-film vacuum-deposition system for nano-layer formation

The Nanotesla Institute

Dr Andrej Žnidaršič, Director: "Our institute was founded in 2006 by several industrial companies (Kolektor Group Idrija, Kolektor Magma Ljubljana and Magneti Ljubljana) to:

- Perform R&D activities in the field of nanomagnetic and nanostructural materials;
- Collaborate with research institutions in advances and at prototype level;
- Help in transferring new technologies to the production line;
- Collaborate between industry and academia on specific industrial R&D projects.

In the proposed project on nanomagnetic particles for cancer detection and thermo-therapy, we aim to develop new drug-delivery systems based on inorganic magnetic nanoparticles, with the ability to overcome the specific biological barriers (toxicity, biocompatibility, etc.) in vitro and in vivo pharmaceutical formulations, which will provide controlled release of the therapeutic drug at the pathological site with maximal therapeutic effects and without side effects. Basic knowledge on delivery systems for effective delivery of therapeutic active ingredients to the specific damaged parts of tissue and knowledge about new molecular targets enables faster development of new therapeutic methods at cell and molecular level. This represents an important contribution to progress in biomedical science."

Dr Andrej Žnidaršič, Director

Balder d.o.o.

Bojan Marin, MSc, director: "Balder, Optoelectronic Elements and Measuring Systems was established in 1997 as a spin-off company of the Jožef Stefan Institute and operates within the Ljubljana Technology Park. The company specialises in production and R&D of electro-optical devices based on Liquid Crystal Display (LCD) technology, such as LCD light-amplitude modulators and LCD active-welding filters. The active (auto-darkening) welding filter is the best selling product. The majority of Balder production is performed by highly trained personnel under clean-room conditions, where the most delicate operations are being carried out. Balder is committed to a high level of overall quality control.

In close co-operation with IJS, Balder has acquired in-depth knowledge of the science as well as the technology for LCD manufacturing. This allows Balder to develop proprietary technological processes and make its own selections of the most suitable materials, along with high-quality suppliers and subcontractors.

Balder is working in the Nanocenter on the basis of its R&D and production activities in the field of vacuum deposition of thin layers (a few nm to a few 100 nm) and computer modelling of the light transition in multilayer optical filters and functional layers in LC light shutters."

The Contribution of Cetis

Participation in the consortium of the Center of Excellence in Nanosciences and Nanotechnology – Nanocenter represents for Cetis an opportunity to raise the technological levels of its products in line with global development. The Nanocenter provides an opportunity for companies to use research equipment for their own development of services and products with higher added value, and at the same time enables access to advanced knowledge.

The objective of Cetis in co-operation of this kind is to obtain concrete knowledge for industrial development, to remain the leading company among the competitors in its field, or even a step ahead. The company will be thus able to realise its mission of being a global information integrator. At Cetis, we are aware that added value is created through investments in development and comprehensive solutions, and successful performance in the market.

For Cetis, as a participant in development and trends, this also means reference to the business field and an opportunity to acquire new business, both at the national and international level. It also represents an opportunity to connect and share knowledge with related companies and institutions.

So far, partnerships of this kind have proved to be very positive for Cetis, and we wish to continue this approach. However, for this success to continue, additional resources are required both for companies and for research institutions. These resources are very important, and we therefore appreciate every contribution from European or Slovenian funds.

Barbara Susin

- Nanomaterials for transport, particularly nanocomposites, smart materials and lubricants.

2.) Nanofacturing technologies for nanotechnology are very diverse. The most important are nanolithographic processing methods and technologies, which directly lead to industrial processes. This type of equipment is developing very rapidly and part of the activity in this centre of excellence is the development of a new and very competi-

The Laboratory for Materials Electrochemistry at the National Institute of Chemistry, Ljubljana

The main research topics pursued in the Laboratory for Materials Electrochemistry at the National Institute of Chemistry, Ljubljana are new materials for energy storage and conversion (batteries, supercapacitors, fuel cells) and materials for health applications (in pharmacy and medicine). In all cases, significant breakthroughs are only possible if the materials are accurately structured on the nano scale. This can be achieved using appropriate nanotechnological procedures. Thus, our participation in the Center of Excellence in Nanoscience and Nanotechnology – Nanocenter is not only reasonable but critical. We believe that the consortium has gathered the critical amount of knowledge needed to carry out cutting-edge research in the fields of nanomaterials and nanotechnologies. We hope that the ongoing co-operation between our laboratory and several other partners within the consortium will further deepen and possibly extend to new topics.

Besides a common body of knowledge, the joint equipment within the consortium is of crucial importance. Without the Nanocenter initiative, many of the essential methods needed for nanotechnological investigation would not be accessible.

Our laboratory has had very positive experience with similar networks – on the European rather than the national level. From 2004 to 2009, we were members of the Alistore Network of Excellence (6th FP). Alistore included 15 European laboratories and 10 companies from the field of lithium batteries. The partnership resulted in a number of excellent research results in different areas relating to batteries. Most importantly, after the funding from Brussels had ended (on 1 January 2009), the network transformed into a European research institute (presently known as ALISTORE-ERI) and was even enlarged through the addition of several new academic and industrial members. Hopefully, we will witness a similar success story in the case of the Nanocenter project.

tive optical nanolithographic (ONL) technology based on recently published multi-colour laser techniques (three papers in Science, May 15, 2009). We also intend to set up facilities for self-assembly technologies as a newly developing area with potential industrial impact, especially in the context of the development of SMEs within Slovenia. The main nanofacturing technologies that the CE will support are:

- Nanoelectronics, molecular electronics devices for nanoelectronics;
- Functional nanostructures in nanocomposites;
- Nanostructured surfaces;
- Multilayer nanostructures;
- Photocatalytic materials;
- One-dimensional materials (mainly inorganic nanotubes in nanowires);
- Hybrid materials;
- Thin-film devices (MEMS, NEMS);
- Molecular technologies;
- Technologies at the level of single atoms and molecules;
- Bionanosensors;
- Nanocomposites and nanoparticles;
- Nanocoatings on surfaces;
- Nanocomposite hard coatings;
- Nanostructures in holographic document-protection;

3.) Characterisation is the core of all progress in nanotechnology, and requires state-of-the-art techniques. The modern characterisation equipment and methods that will be assembled within the CE will allow the use of high technology by the partners that would otherwise be inaccessible to them individually because of prohibitively high cost. The basic equipment for characterisation is being assembled on the needs of the partners and includes microscopy of different kinds, advanced spectroscopic characterisation methods, surface probes of different kinds, nanoscale characterisation tools and advanced techniques for the investigation of dynamic processes in nanomaterials:

- Scanning probe microscopies (STM, AFM, MFM, Kelvin probe etc.);
- Electron microscopy and microanalysis (particularly advanced and combined HRSEM-SPM adapted techniques especially designed for nanomaterials);
- Spectroscopies (from X-rays to THz and STS);
- Diverse optical spectroscopies (Femtosecond spectroscopy, Raman spectroscopy, fluorescence confocal microscopy);

An important aspect is coverage of the safety of new nanomaterials, which will be systematically incorporated into the activities of the CE.

Facility support will be offered on all major equipment via an Internet booking system (based on existing operations), including education and training. This will be organised by the Jozef Stefan International Postgraduate School on a regular basis in the form of "hands-on" short courses and individual on-site training on demand.
An important dimension complementing R&D is the inclusion of postgraduate educational courses in Nanoscience and Nanotechnology at the Jožef Stefan International Postgraduate School at Masters and Doctoral levels.
In addition to intensive activities directly related to training and education, this centre of excellence is expected to provide regular seminars, an annual international conference and other workshops organised by members of the consortium.
The facilities are open to outside users at any time, and are on display (Open days) to the general public on a regular basis, along with Internet presentations and presentations in the popular press.

A summary of the key advantages of the Nanocenter programme:

- The consortium includes all leading teams in the country working in the field of nanotechnology from academia, government research labs and industry;
- Nanotechnology is an area where Slovenia has already shown a very high degree of competitiveness amongst developed nations;
- A programme of high-tech infrastructure development supports a qualitative increase in competitiveness and long-term multiplier effect;
- The establishment of systematic facility support ensures transparent and easy access to young academic researchers from diverse fields and researchers from industry.
- Systematic education in the area of N&N including hands-on training of industrial partners, ensures long-term co-operation and on-site knowledge-exchange on the highest level.

LPKF Laser & Elektronika d.o.o., Naklo

Dr Boštjan Podobnik: "The strategy of LPKF is to ensure high quality in its products by way of a high degree of innovation, made possible by qualified and motivated skilled workers. At the same time, the company ensures that the technologies and materials used are environmentally friendly. The objective of LPKF for the coming years is to maintain leadership on the global market as a manufacturer of environmentally friendly systems for microelectronic circuit prototypes; for this reason, production of laser microprocessing devices has already been established. Further miniaturisation in the world of electronics will increase the need for fast and accurate control over laser-microprocessing processes, together with the need for development of novel micro- and nano-processing processes. The

Dr Boštjan Podobnik

anticipated course of action of the Nanocenter related to research and development of laser nanolithography is therefore aligned with this company strategy, since it will contribute to the initiation of novel technologies for future high-tech product development, as well as to the strengthening of the potential of the workforce and to environmental protection. Research in the Nanocenter, supported by LPKF through technological nanolithography platform implementation and through subsequent research, will contribute to the development of novel micro- and nano-processing technologies and systems, and allow LPKF to remain faithful to its motto: "Quality, innovation, ecology and a skilled workforce".

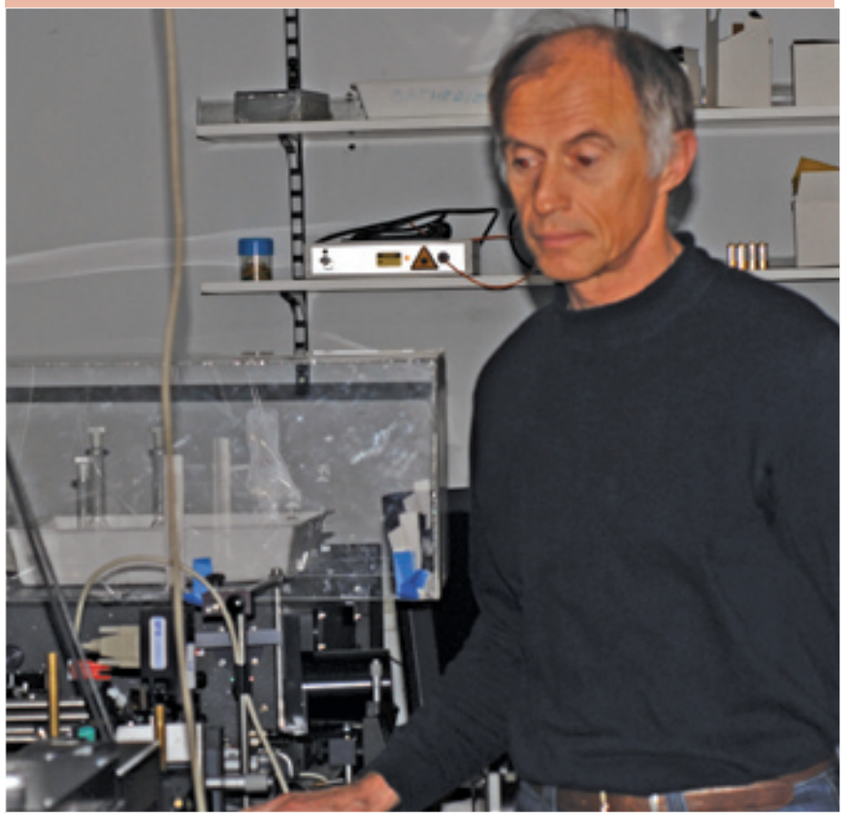
HELIOS Group

Dr Bogdan Znoj, Central R&D of HELIOS group / Development Department for New Technology: "Helios Domžale d.d. is one of the largest producers of coatings in Central Europe, and has been intensively developing new knowledge and technology. Research activities within the company are largely directed to new environmentally friendly technologies and products. New functional coatings that contain nanomaterials or other special additives are also an important new challenge. We are using these to achieve high quality and innovative solutions.

Helios joined the Nanocenter with the aim of accelerating progress in stabilisation of nanoparticles in coatings for different applications. The project brings together a critical mass of researchers and equipment. We thus expect that the Nanocenter will enable us and our partners to develop a faster route to new basic knowledge in one of the world's most promising and topical areas, which has very strong foundations in Slovenia."

FMF

The Faculty of Mathematics and Physics of the University of Ljubljana (FMF) contributes to the Center of Excellence in Nanoscience and Nanotechnology – Nanocenter with investigations of surface nanostructures with nonlinear optical methods, composite structures of soft matter such as liquid crystal-polymer composites, colloid systems and colloidal particle interactions using optical and magnetic tweezers, and self-organisation and manipulation of particles for use in micro-rheological applications. In the last five years, the members of the group have published around 50 papers in SCI journals, including 10 in *Physical Review Letters*. Among the group's successes are the discovery of large diffraction efficiency for cold neutrons of holographic polymer-liquid crystal structures, the study of the dynamic properties of composites of ferroelectric nano-particles and liquid crystals, investigations of guanosine-monophosphate tetramer aggregation, and an analysis of interactions among colloidal particles in liquid crystals using optical and magnetic tweezers. Recently, members of FMF, in collaboration with IJS, set up the first femtosecond laser system for characterisation of surface layers. Some members of the group also founded the company Aresis, which develops and produces systems for laser-beam steering that have already been sold to laboratories in several prestigious universities, such as ETH Zurich and the University of Oxford. The funding of the Nanocenter will make an essential contribution to the research infrastructure for optical and spectroscopic characterisation of nanostructures, particularly with nonlinear femtosecond methods and in magnetic fields. By stimulating continuous contacts among the members of the consortium, the Nanocenter will undoubtedly contribute to collaboration and transfer of knowledge between those involved in basic research and in developing applications.



Prof. Dr Martin Čopič

IPS

The Jožef Stefan International Postgraduate School (IPS)

was established in 2004 as an independent higher-education institution. Its study programmes were approved by the Slovenian National Council for Higher Education. The initiative for the establishment of IPS came from the Jožef Stefan Institute (JSI). It was strongly supported by industry (Gorenje, Kolektor, Salonit) and an international network of co-operating universities and research institutions from the European Union, the USA, Japan, and a number of other countries. JSI provides the central research-educational basis. Within the IPS, invited research institutes, industrial and other enterprises contribute their knowledge and innovation capacities for solving problems. This circle is constantly widening.

The mission of IPS is to provide the highest possible quality postgraduate studies at masters and doctoral levels through a joint research and educational process within an intensive research and development and innovative environment, and to contribute to strengthening of the role of science and high technology in the development potential of society. This can make an essential contribution to economic strength and harmonious social development. IPS acts as a centre of excellence integrating basic research with postgraduate education and development of innovations. Research results are directly integrated into innovative projects for development of production, services, and management. Postgraduate researchers, together with their supervisors from IPS and co-mentors from practice, contribute to new basic research results and to the introduction of science-based innovations.

For all major equipment within the Center of Excellence in Nanoscience and Nanotechnology – Nanocenter, facility support will be offered, including education and training. This will be organised by IPS on a regular basis in the form of "hands-on" short courses and individual on-site training on demand. An important dimension complementing R&D within the Nanocenter is the inclusion of post-graduate educational courses in Nanosciences and Nanotechnologies at IPS at both masters and doctoral level.

Prof Dr Damjana Drobne

University of Ljubljana

Biotechnical Faculty, The Research Group for Nanobiology and Nanotoxicology

Prof. Dr Damjana Drobne: "Biological reactivity or inertness of nanomaterials is one of the major issues in nanobiotechnology. Despite the increased use of nanomaterials in cosmetics, medicine and food industry, there is only very limited knowledge on the mode of action of nanoparticles on biological systems. Therefore, the major goal of the Research Group for Nanobiology and Nanotoxicology is to evaluate the biological reactivity/inertness of nanomaterials with different chemical composition and different surface characteristics. For this purpose, cellular and tissue models will be used, along with in vivo animal exposure.

The role of the common work programme for the Nanocenter is in data and information exchange on regular basis. For example, when studding bio-nano interactions, it is of the utmost importance to work with well-characterised nanoparticles. However, this data can only be provided by those expert groups that are involved in production and manipulation of nanoparticles. The role of a common centre is in formalisation of interdisciplinary co-operation, which supports partnerships that create value in participating organisations in each field. This type of co-operation enables technological and scientific convergence, and results in leading or breakthrough scientific and technological achievements."

CoE

The Centre of Excellence for Integrated Approaches in Chemistry and Biology of Proteins (CIPKeBiP)

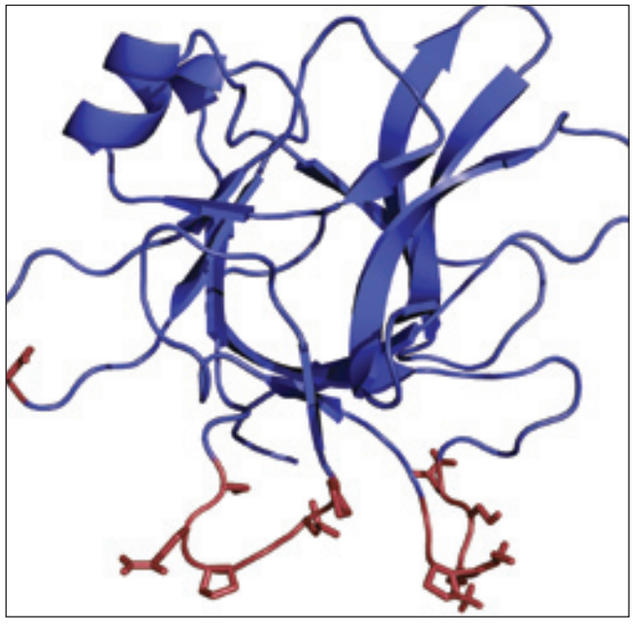
Dušan Turk

The goal of the Centre of Excellence for Integrated Approaches in Chemistry and Biology of Proteins (CIPKeBiP) is to provide a platform for internationally competitive, leading-edge R&D in the area of life sciences, with the focus on mechanisms and pathways of proteins. The centre is built on flexible interdisciplinary networks of researcher working in different fields oriented to solving similar problems. Five academic research institutions (the Jozef Stefan Institute, the University of Ljubljana, the University of Maribor, the University Medical Centre Ljubljana, the Institute of Public Health Maribor) and five industrial entities (Lek Pharmaceuticals d.d., Ljubljana, Medis Ltd., Acies Bio Ltd., Jenko Ltd, TikhePharma Ltd.) have joined forces to combine and jointly develop know how and technological expertise.

Dusan Turk, Project coordinator

We understand that major technology advances, such as high-throughput methods in protein production, biological and technical synthesis of small molecules, high-throughput screening of molecular interactions, X-ray crystallography, proteomics and cell imaging, mean that major investment in infrastructure are required to achieve competitiveness on the international level – scientific as well as industrial. We understand that, for the successful integration of Slovenian science in international research, this process must to be accompanied by major investment in infrastructure. Therefore, over 80% of the grant resources of the centre will be invested into modern equipment as the long-term foundation for competitive research in academic and industrial environments.

The centre will maintain a set of core technologies, such as proteome and metabolic pathway analysis, production of proteins and natural compounds, mass spectrometry, macromolecular crystallography and different forms of advanced microscopy and spectroscopy, calorimetry, organic synthesis, bioinformatics and computational biology. These will be used in studies with a specific biological focus that will drive the development of techno-



Trefoil fold of macrocypins, cysteine and serine protease inhibitors with two binding regions

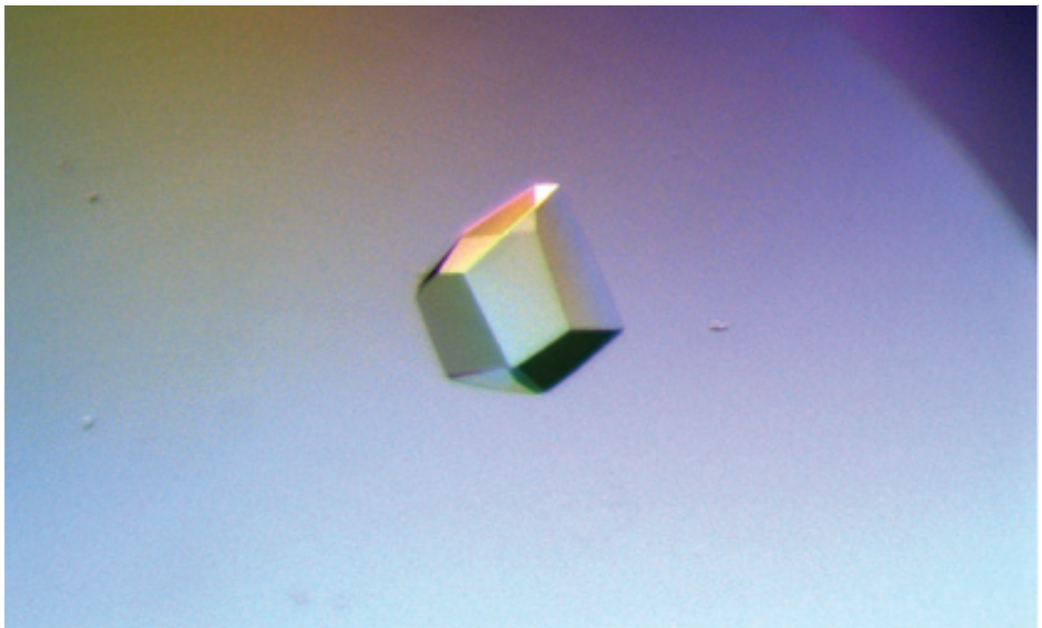
Lek, a Sandoz company

Lek, a Sandoz company, is the pioneer of biopharmaceuticals development and manufacturing in Slovenia. Biopharmaceuticals Lek is Lek's youngest program and constitutes a part of Biopharmaceutical Operations (BPO) of Novartis. Besides being the manufacturing site for biosimilars (biopharmaceuticals marketed after the patent expiration of the originator products), it is positioned within the Novartis company also as a cell line development center of excellence for biosimilars, process development center for cell culture derived biopharmaceuticals and center of excellence for pegylation technology.

High standards set today for the biopharmaceutical industry lead to a very high degree of quality, safety and efficacy of Sandoz products, but they require from us also to constantly develop and implement new sophisticated biotechnological processes and state of the art analytical techniques.

Lek, d.d. has been cooperating with local research institutions and universities for many years and its success is also a joint result of Slovenian science. The participation of Lek, d.d. in the CoE CIPKeBiP represents the oportunity to use the knowledge and expertise resources within such an institution. This is well in line with our activities, which require interdisciplinary team of experts and constantly provide new scientific and technical chalenges. Detailed analytical characterisation of complex therapeutic molecules using state of the art techniques is just one example. The participation in the CoE CIPKeBiP is viewed also as an opportunity to further strengthen the expertise in this exciting area of biotechnology and biosciences in Slovenia and to increase our international competitivness.

From the left: Zvonko Bogdanovski, member of the Lek Board of Management, Dr Violeta Gabrijelčič, Head Biopharmaceuticals at Lek, Vojmir Urlep, President of the Board of Management, Ameet Mallik, Head Biopharmaceuticals at Sandoz at the opening of a new facility for production of state-of-the-art biopharmaceutical active substances.
The new investment of USD 3.75 million at the Mengeš site represents a further strengthening of Lek within the global Sandoz biopharmaceutical development and production network. Mengeš is one of the three main biopharmaceutical development and production centres within Sandoz worldwide, and a centre of excellence for cell culture and modified-protein technology.



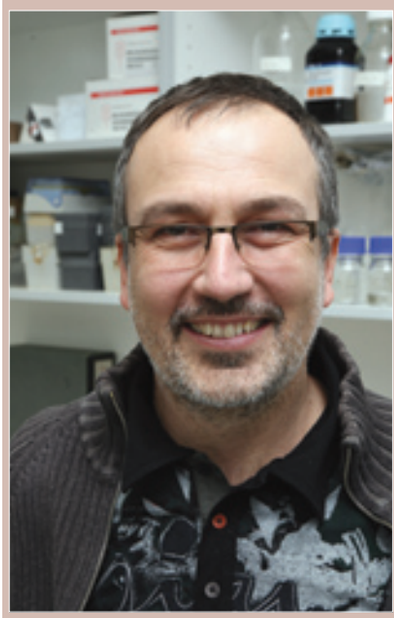
logical and methodological expertise. The centre aims to tackle several key biomedical problems in a collaborative effort, shaping up teams to maximise output. The work will be organised into four research projects, each pursuing specific goals and scientific questions:

- ◊ Mechanisms and pathways of immune response;
- ◊ Inter- and intra-cellular communications;
- ◊ Adaptation mechanisms of extremophiles to environment;
- ◊ Protein Bank: storage and production of proteins.

Within the **"Mechanisms and pathways of immune response"** work package we plan to gain novel insights and improved knowledge of molecular mechanisms of immune response. The studies will provide inside into infection and disease state-specific pathways and players suggesting new targets for therapies and diagnostics of infectious and autoimmune diseases and cancer, as well as immune-system suppression in cases of autoimmune disease and organ transplants. The intermolecular events and pathways will be studied at various levels, combining biochemical and structural analysis, cell and tissue imaging and microscopy. The work programme is organised into three subpackages, each covering a specific biological aspect: "Generic mechanisms of immune response" aims to deliver novel insights and improved knowledge of molecular mechanisms of immune response, in particular, molecules of endocytic pathway, MHC class II mediated antigen presentation, and their characteristics and interactions. "Pathogens and their interactions with the host" aims to deliver novel insights and revealing new players into host factors (enzymes and receptors of antigen recognition) and bacterial virulence factors. These molecules, as well as their their surface components, will be identified and characterised. Finally, the work package "Modulation of immune response by small molecules" aims to develop new and modified immunomodulating molecules. It encompasses synthesis, as well as development of in vitro and in situ validation assays.

Within the "Intra- and inter-cellular communication" work package, we will study the function of subcellular compartments, specifically vesicles of the secretory/endosomal pathway in different processes of intra-cellular and inter-cellular communication. Particular attention will be given to intersections of organelle-mediated signalling, protein-mediated signalling and signalling pathways as targets of small molecules, each representing a single subpackage.

Within the **"Adaptation mechanisms of extremophiles to environment"** work package, we will investigate



Boris Turk

Proteolysis and protease signaling pathways

Boris Turk, Proteolysis group, Department of Biochemistry and Molecular and Structural Biology, Jozef Stefan Institute: "The research group has major expertise in proteases and the role and regulation of proteolysis in physiological and pathophysiological processes. Proteases, among them the cysteine cathepsins, which reside in the endosomal/lysosomal system and are the major subject of our studies, have been found to have a critical role in immune response, cell death and various aspects of tumour formation. Our studies are focused on elucidation of the signalling pathways that the cathepsins control, including immune response, autophagy, apoptosis, necrosis and tumour progression, and also involve in vivo imaging of protease activities, identification and validation of physiological cathepsin substrates and modulation of their activities by compounds, including inhibitors or cell-death triggers.

Within the centre of excellence, we will evaluate compounds generated by other partners in the cellular models for their suitability to target the selected signalling pathways and their potential cytotoxicity, which are critical parameters in drug discovery. We will also apply novel and advanced technologies (proteomics, advanced microscopy, structural biology) in elucidation of

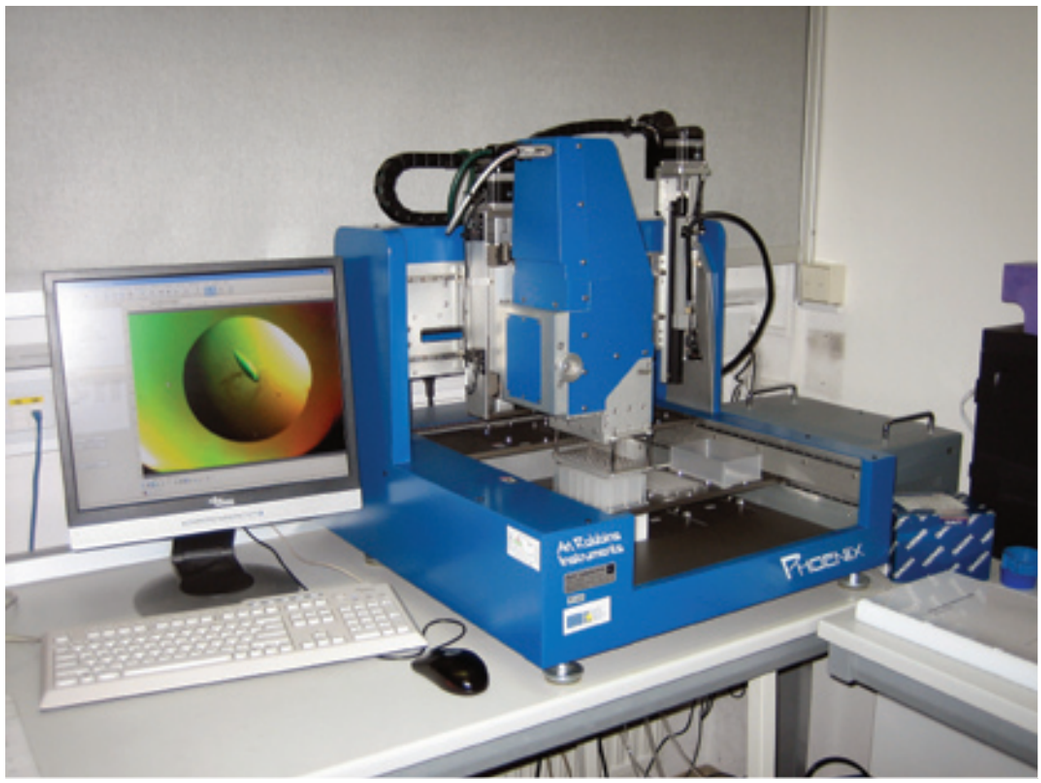
proteins involved in adaptation to extreme conditions, particularly the components of signalling pathways in halotolerant/halophilic fungi, their protein-protein interactions and interactions with their targets.

The overall goal of the "Protein bank" work package is to set up a state-of-the-art infrastructure using parallel approaches for continuous expression, production and storage of proteins and their complexes in prokaryotic and eukaryotic systems, a task that would otherwise be too costly and laborious for individual laboratories.

cellular signalling pathways at the molecular level with major focus on cancer and immune response. Based on our current expertise, we will combine the two by studying the novel molecules for their potential as chemotherapeutics in cancer treatment.

Proteomics and protein identification

The second part of our work will focus on post-translational protein modifications such as phosphorylation, glycosylation and proteolytical cleavage, which are among the main physiological regulators of protein function. Structural studies of proteins depend on fast and accurate determination of their primary sequence and on identification of their post-translational modifications. Currently, high-resolution mass spectrometry is the only methodology allowing high-throughput analysis of a large number of proteins and their functional mutants in complex biological samples. Within the work of the centre of excellence, this type of analysis will be applied not only to identification of post-translational modifications in proteins, but also to analysis of intact proteins and their complexes with the long-term goal of unravelling signalling pathways. Through this process, we hope to identify new drug targets and to perform validation of several potential targets."



The nano robot

Super-resolution microscopy and cell physiology at LN-MCP

Robert Zorec, Institute of Pathophysiology, Faculty of Medicine, University of Ljubljana:

"While the other groups within the centre of excellence focus on the biology and purification of proteins, our group will be looking at protein expression/production in single cells. Subcellular physiology of secretory organelles is crucial to the understanding of the nature of subcellular traffic and cell-to-cell communication and also for the production of recombinant proteins. A powerful approach in studying this is optophysiology using fluorescence microscopy and electrophysiology to monitor minute ionic currents through the membrane and changes in the membrane area by electrical capacitance. Partners in the centre of excellence run an advanced optical microscopy facility, equipped with two confocal microscopes, two high-temporal-resolution microscopes and several fluorescent microscopes equipped with FRET applications, amplifiers and signal-acquisition systems and manipulators for electrophysiology and microinjection. Confocal microscopy offers several advantages over conventional fluorescence microscopes in viewing subcellular structures. Information is collected from a well-defined optical section; thus out-of-focus fluorescence is eliminated, which results in an increase in contrast, clarity and detection. Stacks of optical sections taken at successive focal planes can be reconstructed to produce a three-dimensional view of a specimen. Thus, confocal microscopy provides the means to observe structural components and physiological processes of live cells and tissues in three-dimensional space without physical sectioning. Repetitive imaging (a time series of images), allow visualisation and analysis of physiological processes in living cells. Moreover, the spectral detector records the fluorescence spectrum at each three-dimensional pixel in time, which collectively generates five-dimensional data for the sample. Future research equipment for nano-optical microscopy will substantially increase the spatial resolution of fluorescent images. This equipment represents the-state-of-the-art in optics, electronics and laser technology. The equipment will allow us to resolve structural and functional entities in cells beyond the Abbe diffraction limit."

Organelle-mediated signalling in endocrine tissue models

Marjan Rupnik. Medical Faculty, University of Maribor: "Our primary goal is to better understand the role(s) of signalling pathways leading to exocytosis of insulin. In particular, we plan to assess the role of the protein kinases on signalling pathways in the context of intact endocrine tissue, using fresh tissue slices. Our other tissue models include exocrine pancreas, adrenal medulla and pituitary gland. We pioneered the development of the endocrine tissue-slice approach and serve as a reference laboratory for endocrine tissue-slice preparations. We monitor the physiological status of the cells within the tissue slices by measuring ion channels, the processes of exocytosis and endocytosis using electrophysiology and the dynamics of changes of intracellular ions using life imaging of the cells within the tissue using classical microscopy and advanced nonlinear microscopy."

TikhePharma Ltd

Mateja Urlep: "TikhePharma joined the centre of excellence to take an active part in dissemination of the results of basic protein research in Slovenia, aiming for greater acceptance by the international pharmaceutical industry's research groups. With 20 years of experience from the pharmaceutical industry in the field of biological medicinal products, we have much to offer the consortium of research partners in the field of positioning, project management and communication strategy. Our aim is to create awareness of the knowledge and expertise to identify key projects that will attract the interest of pharmaceutical researchers."

Jožef Stefan Institute

Stojan Stavber, Laboratory for Organic and Bioorganic Chemistry:

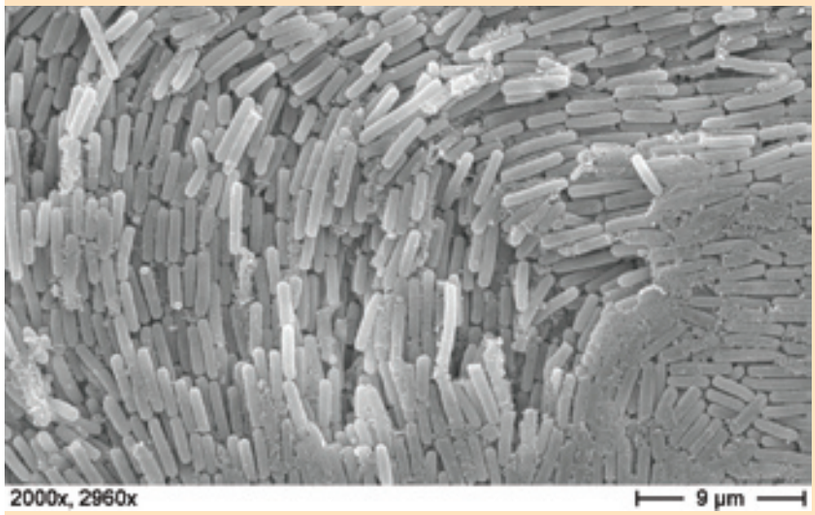
"Concern over environmental pollution, risks to human health and sustainable development has prompted chemists to search for more environmentally friendly methods to replace traditional ones. The concept of green chemistry emerged a decade ago and it has become increasingly important to apply principles of this kind in every area of science. Some of the major challenges include organic chemical reactions involving the principle of atom economy, efficient catalytic methodologies compared to stoichiometric reagents, suitability of safer alternative reaction media (ionic liquids, fluorous liquids or water in place of volatile organic solvents, and reactions under solvent-free reaction conditions). With this in mind, the programme will mainly deal with problems in "green organic chemistry" and "low-carbon organic chemistry" which is the highest recent priority in our laboratory. The following research activities are proposed:

A) Halogenation of organic compounds in aqueous media

This is an open issue in the field of organohalogenic chemistry and requires intensive research. In our continuing efforts, we will investigate

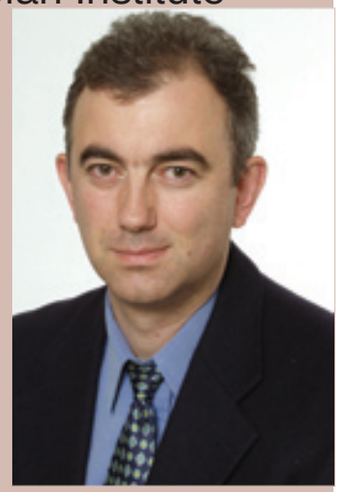
Institute of Public Health Maribor

Maja Rupnik: "The Institute of Public Health Maribor is the regional centre for social medicine, epidemiology, hygiene, health ecology, clinical microbiological diagnostic and food microbiology, as well as chemical analysis of environmental pollutants. The institute is involved in several national and EU research projects. Its staff teach at the University of Maribor and elsewhere. The research group at the Centre for Microbiology has expertise in bacterial pathogens with a particular focus on clostridia, clostridial toxins and other virulence factors and their role in host-pathogen interactions. Research also covers characterisation of specific microbial populations with molecular-typing methods and applications of advanced molecular methods for analysis of complex microbial populations. Within the centre of excellence, we will investigate the differences between pathogens causing severe and milder forms of the disease, hoping to use these properties as targets for diagnostics and treatments."



Clostridium difficile

The Jožef Stefan Institute



Sašo Džeroski, Department of Knowledge Technologies:

"Our group has extensive expertise in the development of data-analysis methods (data mining, machine learning) for integrative analysis of complex and heterogeneous data. It also has ample experience in applying data-analysis methods to real-world problems in the areas of environmental sciences (incl. ecology) and life sciences (incl. bioinformatics and systems biology). Especially relevant is experience in integrative analysis of high-throughput data generated by different "omics" disciplines, ranging from genomics through transcriptomics and proteomics to phenomics. Within the centre of excellence, our group will address important data-analysis problems arising within the four basic research projects of the centre and related projects involving the centre's partners. The types of data expected to be available include mass-spectrometry data, protein-protein interaction networks, and time series of cell images. Potential data-analysis problems to address include genome-wide prediction of gene/protein function, reconstruction of pathways and the discovery of genotype-phenotype relations from genomic (sequence) and phenomic (imaging) data."

selective halogenation of organic compounds in aqueous media, with special attention to oxidative halogenation, which is the most similar to that which exists in natural processes. As a source of halogen atoms, halogenides will mostly be used, while air oxygen or aqueous hydrogen peroxide as biomimetic oxidants will be applied. Further investigations of the reactions of N-F reagents with organic compounds in aqueous media will also be performed.

B) Aerobic and other biomimetic oxidation of organic compounds in water or under solvent-free conditions

Oxidation is one of the basic transformation of organic compounds and use of air oxygen or aqueous hydrogen peroxide for these reactions represents an eco-friendly protocol diminishing the carbon content of the overall process. The use of metallic (Ce(IV); Re(VIII); oxymetalates) or non-metallic ($NaNO_2$, HNO_3, flavone) catalysts will be investigated for use of aerobic oxidation of alcohols, aldehydes, ketones, and sulphides, and in the last case also in a stereospecific way.

C) Organic peroxides are important bioactive compounds since they release active oxygen species in the organism and thus generate radicals. Research is focused on structure/activity studies on antimalarial cyclic peroxides (1,2,4,5-tetraoxanes), which also provide antiproliferative properties. Our continuing research in the field of organic peroxides will be oriented into new synthetic methods for selective preparation of various classes of peroxides directly from carbonyl compounds and hydrogen peroxides.

The main scope of our efforts in the framework of the centre of excellence is the invention and development of chemical processes, which as much as possible mimic natural non-enzymatic processes, are performed in aqueous or some other alternative media, and create low levels of waste. In one sentence: we intend to discover and develop environmentally benign organic chemistry, or organic chemistry for sustainable development."

Secretory phospholipases A2 in health and disease.

Igor Križaj, Department of Molecular and Biomedical Sciences, Jožef Stefan Institute:

"One of the main research topics of the group is the study of secretory phospholipases A2 (sPLA2s) originating from either animal venoms or mammalian tissues. These sPLA2s are esterases that hydrolyse the sn-2 ester bond of glycerophospholipids. The mammalian genome contains 10 enzymatically active sPLA2s and two sPLA2-related proteins devoid of lipolytic activity. Accumulating evidence has shown that some of these enzymes are responsible for

Dr Adrijana Leonardi

the release of arachidonic acid from cellular phospholipids, which is then involved in the biosynthesis of inflammatory eicosanoids. Recent results also suggest the involvement of one or more sPLA2s in atherosclerosis and cancer. In addition, the mammalian genome encodes several types of sPLA2-binding proteins, and there is increasing evidence that sPLA2s may have functions related to binding to cellular target proteins in a manner independent of their enzymatic activity.

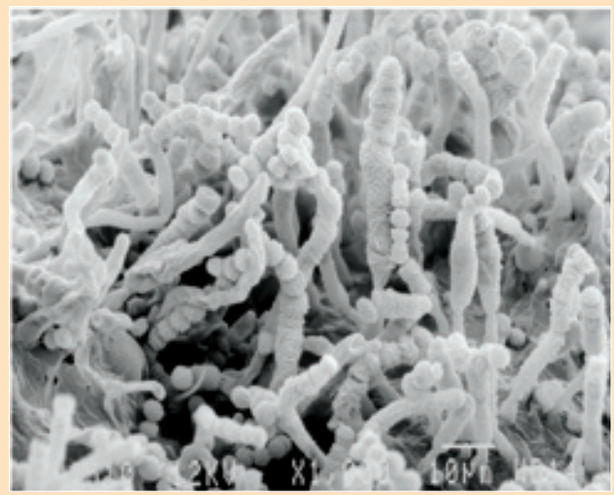
Within the centre of excellence we will take advantage of the most recent and advanced technologies and expertise, particularly advanced microscopy techniques and mass spectrometry, to deepen our knowledge and understanding of two sPLA2-related topics. Our first focus will be on toxic snake-venom sPLA2s, particularly those endowed with presynaptic neurotoxicity, to gain deeper insight into how these proteins influence nerve function (e.g. exo- and endocytosis, mitochondrial function). Our second focus will be on the role of endogenous sPLA2s in cell proliferation, apoptosis and signalling in mammalian cells. In this respect, we will first concentrate on the pathological changes and the potential role of sPLA2s in breast cancer.

Protein identification and characterisation. The group has more than 20 years of tradition in protein primary-structure determination, and is still the only protein-sequencing expert group in Slovenia. Our second contribution in the centre of excellence will thus be devoted to protein identification and characterisation using automated Edman degradation."

Extremophilic organisms

Nina Gunde-Cimerman and Anica Plemenitas, Biotechnical and Medical Faculty, University of Ljubljana:

"Harsh environments cause adaptations of organisms and provide unique models for unravelling the genetic basis of adaptive evolution. Hypersaline environments, including solar salterns, are extreme habitats that are populated with organisms capable of adapting to these extreme conditions. Such environments are populated with halotolerant Archaea, Bacteria, and Algae, and by high fungal biodiversity of phylogenetically unrelated groups of halotolerant and halophilic fungi, as discovered several years ago by the Gunde-Cimerman group. The groups of Nina Gunde-Cimerman from the Biotechnical faculty and Ana Plemenitaš from the Faculty of Medicine of the University of Ljubljana, have



Wallemia ichtyophaga

since collaborated on the study of physiological and molecular adaptations in model organisms.

One of the most studied to date is the black yeast Hortaewa werneckii, the dominant species found in salterns. H. werneckii is able to adapt to the widest range of salinities reported. As such, it is a highly appropriate model organism to study salt tolerance, as well as mechanisms of adaptations to drastic changes in salt concentrations in eukaryotes.
Molecular studies on H. werneckii have revealed important new features in proteins of the HOG signal-transduction pathway involved in sensing and responding to increased NaCl and this has resulted in an EU patent report. Novel features have been identified in the protein components of this pathway, suggesting different and unique mechanisms of adaptation.
Improvement of plant salt tolerance is becoming an urgent need because of salinisation of agricultural areas. This tolerance may be achieved by inserting genes from halotolerant species into crops. Particularly interesting targets are gene products that are modulated by sodium influx in a high-salinity environment. H. werneckii is a potential source of osmoprotective genes for improvement of yeast, in particular S. cerevisiae, as well as plants. Besides increased tolerance to high NaCl concentrations, increased tolerance to UV, low temperatures and oxidative stress were also observed in H. werneckii, making it a potential source of genes for improvement of S. cerevisiae."

Emericella stellamaris

Acies Bio Ltd

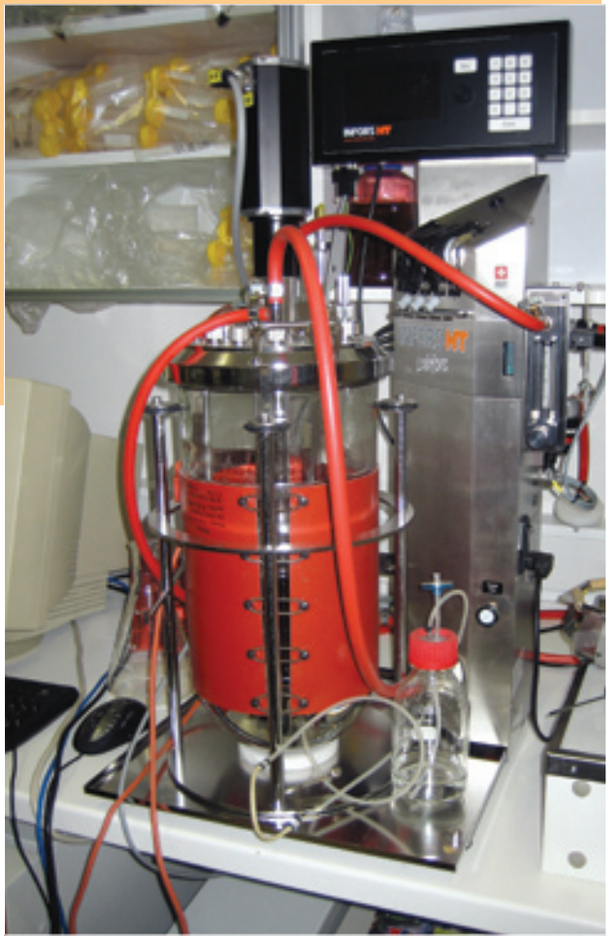
Enej Kuscer and Hrvoje Petkovic:

"Acies Bio is a biotechnology R&D company working primarily in the field of pharmaceutical biotechnology on in-house and collaborative projects, with national and international industrial partners, on manipulation of the pathways involved in biosynthesis of antibiotics and other secondary metabolites, metabolic engineering, strain improvement and process-development projects. Acies Bio is also developing novel secondary-metabolite bioactive compounds and industrially relevant enzymes using biosynthetic engineering and a "green chemistry" approach in general. Within the centre of excellence, Acies Bio's work will focus primarily on interactions of small-molecule compounds produced by biological and chemical synthesis with target proteins and signalling pathways. Selected drug leads will be used to study relevant biological pathways and proteins involved in selected cellular processes, thus providing valuable data for drug discovery and development. As an industrial biotechnology SME partner, Acies Bio will also play an important role in supporting the commercialisation of the expected applicative results of the centre."

Jožef Stefan Institute

Dušan Turk, Structural Biology Group, Department of Biochemistry and Molecular and Structural Biology:

"Structural studies combined with biochemical, molecular and cell biology and physiological approaches enable us to gain insight into the mechanisms of interactions of molecules, their specificity and physiological role. Insight into the three-dimensional structure of a macromolecule at the atomic level enables us to combine the information from the sequence of building blocks (amino-acid residues and nucleic acids) with their spatial arrangement. Its availability is nowadays an essential, standard part of research tackling mechanisms of biological processes and is of key relevance for planning further research steps and their technological exploitation in drug discovery and protection of the environment and crops. Our studies address the mechanisms of adaptive immunity, the so-called endocytic pathways."



Bioreaktor

CoE

The Future of Energy is in Lithium and Hydrogen Technologies

Miran Gaberščček
Rada Drnovšek

It is a fact that fossil fuels are limited and the whole world is facing the challenge of how to change its dependence on fossil fuels in everyday life. The use of fossil fuels in the last decades in transport and industry has probably significantly contributed to climate change during the last few years. The EU and Slovenia itself are looking for answers to these challenges and one possible answer is investing funds into research of new technologies for the use and storage of renewable energy. In this spirit, the major emphasis in the Slovenian call for proposals for Centres of Excellence published in May 2009 was on promoting activities that would lead to a future low-carbon society, that is a society based on technologies using sources other than fossil fuels. From this perspective, it is no wonder that the Centre of Excellence for Low-carbon Technologies (CoE NOT) has been selected to receive this funding. The ultimate goal of CoE NOT is to research, develop and extend low-carbon technologies to the whole of Slovenian society and wider. CoE NOT consists of 22 partners, of which 12 are academic laboratories (located at the National Institute of Chemistry (NIC), the Jožef Stefan Institute, the University of Ljubljana and the University of Nova Gorica), while 10 partners (Cinkarna, Domel, INEA, Iskra Tela, Mebius, Silkem, Petrol, HSE and RCVT) are Slovene companies working in the field of new energy technologies. NIC is the co-ordinator of this consortium and was co-ordinating the preparation of the application and will be co-ordinating further work. Partners of the consortium plan to organise regular workshops where they will report about their research and development achievements and future plans. We believe this kind of work and regular meetings will help us to share the experiences gained during the research process. CoE NOT has set four main ambitious goals:

a) to link the leading Slovenian researchers and producers in the field of new technologies that will replace current technologies based on fossil fuels,
b) to carry out intensive and coherent R&D projects that will allow for fast advances in the research field defined under point a),
c) to encourage the co-operation of CoE partners with external partners (both national and international),
d) to acquire further financial resources that will further intensify R&D in the field and allow continuation of the CoE programme after the completion of the current funding at the end of 2013.

CoE NOT is joining together key Slovene potentials in the field of new, low-carbon energy sources and the use of such sources in both stationary and mobile applications. Solar energy will be converted either to electricity, which will then be stored in secondary batteries and supercapacitors (Lithium Technologies) or, alternatively, into hydrogen which will then be used to power fuel cells (Hydrogen Technologies). Lithium and Hydrogen technologies can be viewed as a winning combination that will cover a substantial portion of energy needs, in particular in future hybrid and electric

Miran Gaberščček, PhD

Rada Drnovšek

HSE

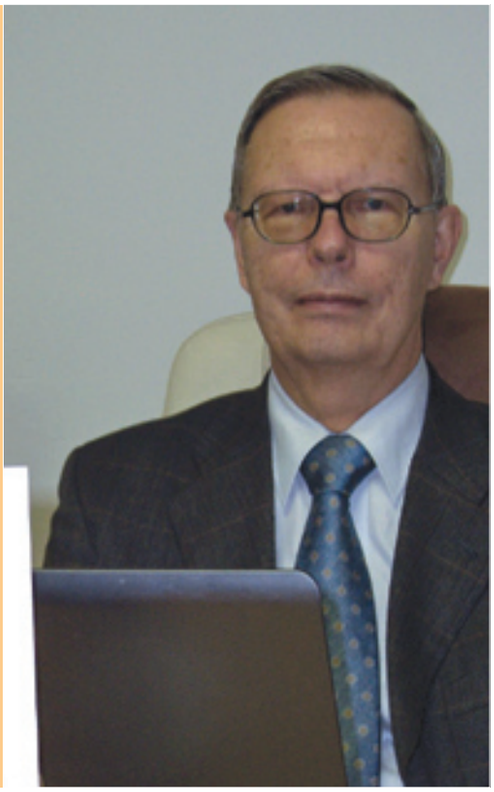
Borut Meh, General Manager of HSE:
"In 2001, the Slovenian Government established HSE as an integrated entity of six companies, as a result of, and in response to, the processes of market deregulation. Accordingly, HSE was to become the leader and key factor in the transformation of the Slovenian power-generation sector. Through participation in CoE NOT, HSE has access to the latest results of research on hydrogen technologies and their application in practice and can follow guidelines on the development of hydrogen technology, which indicate the possibility of a transition to a low carbon society in the future. In particular, HSE is interested in the area of hydrogen technology in decentralised systems, combined heat and power, the use of hydrogen in energy supply and the production of hydrogen as a vehicle for peak energy. TEŠ, which is a member of the HSE, is also participating in CoE NOT as a consortium partner. HSE and TEŠ will work together with the Faculty of Mechanical Engineering and the CoE for hydrogen technology in the field of lithium and hydrogen technology, where it will undertake demonstration projects that show an alternative way of meeting electricity demands."

Termoelektrarna Šoštanj d.o.o.

Uroš Rotnik, PhD, Director:
"The Termoelektrarna Šoštanj thermal power plant is a classical producer of electrical and thermal energy based on lignite processing. We have mastered the related technological procedures, yet are fully aware of the consequences of our activity. From another point of view, we are a CO2 producer making a living of the by-product of the activity, selling electrical and thermal energy. The willingness and knowledge to make a change has always been present with us, along with the ideas. By entering CoE NOT, a path is being opened for us that will lead us to answers to the open questions and to completing the goals we are constantly setting for ourselves. The guarantee of success is in the concentration of knowledge, funds, equipment and a unified willingness to implement development ideas.

Mebius d.o.o

Stanko Hočevar, PhD: "As a relatively new, small enterprise with highly educated and innovative staff, Mebius will gain from joining CoE NOT through the chance to co-operate with other companies, research institutes and universities on joint projects and initiatives to enhance the development and promotion of hydrogen and related technologies. Sharing human resources, expertise and equipment among the members of CoE NOT are important reasons for Mebius to join this initiative. Cooperation within CoE NOT should support successful introduction of low-carbon technologies to the market and society, and help develop infrastructure and products that will revolutionise everyday life, moving us towards a greener, cleaner, low-pollution and sustainable future. Within CoE NOT, the most important goal for Mebius is to commercialise its intellectual property, know-how and products in fuel cells core technology."



vehicles, in energy supply for houses, etc. In the intermediate period, the same energy needs will be covered by alternative low-carbon solutions, such as water power, biomass, etc. CoE NOT covers all levels – from theory to basic materials research, development of technologies and, finally, engineering leading to the production of real devices. The topic of our CoE fits into three (of five) priority topics: technologies for a sustainable economy, advanced synthetic and non-metallic materials and nanotechnologies, and complex systems and innovative technologies. The advantages of this CoE are its orientation towards –low-carbon technologies, multidisciplinarity and also the complementary skills of the partners, who offer a wide range of the skills needed for development of solar, lithium and hydrogen technologies.
Within the CoE NOT, we have two major areas of projects: lithium technologies and hydrogen technologies.

Lithium technologies

In recent years, research on new materials for lithium and solar technologies has witnessed extreme intensification. One of the reasons is the decision of major world car producers to enhance the development of hybrid and full electric vehicles. With decreasing fossil

Cinkarna Celje

Andrej Lubej, PhD, manager of PE Kemija Celje:

"We sincerely believe in the organisational model presented by the CoE as a model of efficient and productive cooperation between educational and research institutions and the industrial sphere. The research programme of CoE NOT is in our opinion visionary and could potentially serve as an opportunity to gain high-tech knowledge that could be used for developing some new highly competitive industrial products.
In general, we expect a deep and extensive collaboration not only with the National Institute of Chemistry, but also with the other research and industrial partners of CoE NOT. As a producer of titanium dioxide, Cinkarna Celje is interested in research activities in the field of photovoltaic hydrogen production and storage of electric charge connected with the use of ultrafine titanium dioxide. Our main aim is developing mechanisms and properties that would favour the use of titanium dioxide in these processes."
Rok Vodnik, Board member, Petrol d.d., Ljubljana: "Petrol d.d., Ljubljana joined the CoE NOT to take an active part in research towards greater future use of hydrogen fuel in vehicles. With over 60 years of experience in storage and distribution of liquid petroleum fuels, we have much technical and practical knowledge to offer. Our firm goal is to build the first hydrogen refuelling station for public use in Slovenia within the next four years. Thereby, we also want to contribute to greater environmental awareness and greater sustainability for our economy."

Research Centre for Hydrogen T echnologies

Matjaž Čemažar, MSc, Acting Director:

"The idea of CoE NOT is complementary to the idea of RCVT, especially in the area of the hydrogen route to low-carbon technologies.
The main goal of the CoE is providing conditions for:

- basic research on core and support technologies,
- transfer of knowledge and expertise among the partners,
- development in the field of hydrogen and fuel cells in Slovenia through implementation of projects and organising expert meetings on hydrogen technology.

The main activities of CoE NOT are expected to focus on the goal of combating climate change and boosting Slovenian energy security and competitiveness."

Domel d.d.

Matjaž Čemažar, MSc, Director, Research and Development:

"Domel d.d. is a global development supplier of accomplished solutions based on electro-motors and their upgrading. Domel is focused on air-delivery systems driven by electronically commutated motors for many industries and also on fuel cells.
The main goal of the new CoE NOT is to link industry with institutional knowledge, experiences and capacities. We will work towards the drawing up of a new energy path towards a more secure, sustainable and low-carbon economy, for the benefit of all users."

Silkem d.o.o., Kidričevo

Dr Andrej Horvat, Head of Project: "Zeolite 4A – a synthetic product with special characteristics produced an ecological revolution in the 80s as it successfully replaced the environmentally harmful phosphates in detergents. Thirty years later, zeolites are among the most promising materials for storage of hydrogen as one of the cleanest sources of fuel for vehicles, and for heat storage, where solar energy is accumulated in the summer time and released during the winter period. Another interesting and fast-growing market for zeolite materials is WMA (Warm Mix Asphalt), which minimises energy use and harmful emissions. These are several of the reasons why Silkem, a well-known European zeolite producer, is excited to be involved in the CO-NOT partnership in the next few years."

Petrol d.d.

Rok Vodnik, Board member, Petrol d.d., Ljubljana: "Petrol d.d., Ljubljana joined the CoE NOT to take an active part in research towards greater future use of hydrogen fuel in vehicles. With over 60 years of experience in storage and distribution of liquid petroleum fuels, we have much technical and practical knowledge to offer. Our firm goal is to build the first hydrogen refuelling station for public use in Slovenia within the next four years. Thereby, we also want to contribute to greater environmental awareness and greater sustainability for our economy."

fuel resources and increasing environmental pollution, batteries are rapidly gaining attention as one of the most attractive future power sources to replace a substantial portion of the energy demands that are currently covered by fossil fuels. Of all possible storage devices, lithium-based devices are the most attractive because they have the highest theoretical energy density, have no memory effect and have the lowest degree of self-discharge. At the same time, potential reserves of lithium are quite large. We intend to produce the electricity needed for recharging of batteries using solar technologies. Among the various possibilities, we are focusing on the development of Graetzel cells, which have great potential to replace current silicon-based solar cells. Alternatively, we are also investigating the possibility of exploiting thermal solar energy. Partners that will work on this project are already connected to many other groups and companies that also cover some of the topics proposed in this CoE. On the international level, the present partners have connections to companies such as Renault, Volkswagen, Honeywell, Umicore, Saft, Varta, etc. Besides national governments and the car companies, the EU has also recognised the significance of these green technologies, and so more and more money is available for these purposes.

Hydrogen technologies

Hydrogen technologies, including fuel cell development, are nowadays recognised as one of the most relevant areas of activity towards ensuring long-term and environmentally friendly energy production. Financing of this research area is increasing exponentially and currently exceeds EUR one billion per year.

There is one sizeable and holistic R&D Project within the field of hydrogen technologies: "Holistic design of PEM fuel-cell based systems". The project includes all modes of research, from basic materials investigation to production of prototypes, and even development of larger modules. Finally, the project aims at the real implementation of hydrogen technologies in everyday life in Slovenia. The development of the whole system of activities requires a holistic approach, which takes into account requirements on reliability, durability and safety, together with requirements for high energy and cost efficiency. Partners in the project have

INEA d.o.o.

Zoran Marinšek, PhD, Manager, Research and Development:

"INEA is a leading Slovenian company in the field of automation, process control and manufacturing informatics. Since 1987, INEA has been developing integrated solutions for ecology and energy systems and is a global provider of special solutions in the field of process control technologies. CoE NOT gives us an opportunity to continue our work in the field of hydrogen technologies, particularly in the development of advanced fuel-cell control systems, fuel cell-based cogeneration and UPS systems and the development of alternative reforming systems. We see balanced development and integration of various technologies, focused on final products, and strengthened by a mixed team of researchers from both academic institutions and industry, as a particular advantage of work in the CoE.

We believe that results stemming from the CoE NOT R&D partnership will give us an opportunity to become, together with our CoE NOT partners, an important and recognised player in the global fuel-cell equipment supply chains."

already established collaborations with various European and American companies active in the field of development and applications of fuel cells (Ballard, Hydrogenetics, PlugPower, Vaillant, NedStack) in the form of different projects and contracts. All partners are also members of the Slovenian platform SHIFC – Technological platforms for hydrogen technologies and fuel cells.

Our vision of CoE is very clear and ambitious. We do not only wish to work closely together until 2013, but even further and to win the support of the Slovenian state and economy and the EU.

Iskra TELA d.d

Marjan Valand, Iskra TELA d.d., Ljubljana:
"Our battery market is shifting towards renewable energy sources, and therefore we have started activities that will steadily replace our batteries with a PV source coupled with a rechargeable battery. CoE NOT can help us with equipment that would otherwise be difficult to obtain. We also see CoE NOT as an organisation where ideas and knowledge can be shared among participants. We will be looking to enhance our solutions with solutions from others in CoE NOT."

Solar thermal collectors

Prof. Dr Boris Orel, Head of the Laboratory for the Spectroscopy of Materials:
"One of the research topics in the Laboratory for the Sspectroscopy of Mmaterials is the synthesis of advanced materials from colloidal solutions using "wet" chemical processes – sol-gel processes. Our work has resulted in novel ways of using these materials as thin layers for absorbers in solar thermal collectors.
Sloveniane producers of solar thermal collectors import the vital parts such as the thermal absorbers from the global market. Using sol-gel technology, the National Institute of Chemistry, Slovenia, has developed a protective layer that prevents the corrosive decay of the original ceramic-metal (cermet) coating. At the same time, the new coating improves the mechanical properties and maintains the basic optical characteristics, i.e. spectral selectivity, of the original cermet. These properties are a result of the composition of the selected nanocomposite composition, the appropriate reactivity, the compact nature, and lack of porosity of the new coating, and, above all, its thickness, which does not exceed 30 nm. The new coating has beenwas patent protected and the patent sold to foreign producers of solar absorbers."

Prof. Dr. Boris Orel, Head of the Laboratory for the Spectroscopy of Materials

CoE for Polymer Materials and Technologies (CoE PoliMaT)

Polymers for Better and Richer Life

Majda Žigon and Andrej Kržan

Polymers and plastics represent a unique success story in the world of materials. Approximately one century after their discovery, they have made an indelible mark on virtually all areas of human activity: from packaging, clothing and transportation to sports, healthcare and construction. Not surprisingly, the annual global production of polymers and plastics by volume has long surpassed traditional materials, such as steel.

The most remarkable part of this story of success is that polymers and plastics are true man-made materials based on science. And most recent developments show that science will continue to be the principal force in the future of polymers and plastics – for example, with new nano-reinforced or nano-modified materials that deliver improved properties with smaller material and energy investments. Science is also critical in efforts to raise the sustainability, biodegradability and the use of renewable resources, and these efforts are integrating artificial polymers into natural material cycles and reducing their environmental impact.

This development was closely paralleled in Slovenia, where polymers and plastics play a significant role in industrial production, particularly in two areas: the production of polymers for paints, coatings and adhesives, and the processing of plastics by a large number of companies of all sizes. Both sectors combined create a large income and employ a substantial workforce, giving them even more importance. A number of academic and research institutes, as well as the most ambitious companies have joined in a consortium of 22 partners to establish the Centre of Excellence for Polymer Materials and Technology – CoE PoliMaT (Table 1). The centre brings together the previously dispersed capacities of leading Slovenian research groups from public institutes and academia, as well as small, medium and large enterprises from the area of polymeric materials. The consortium was co-ordinated by Prof. Majda Žigon, while the managing director of the centre is Dr Andrej Kržan, both from the Laboratory of Polymer Chemistry and Technology at the National Institute of Chemistry in Ljubljana.

The activities of the centre are multidisciplinary and are directed towards the priority goal of a low-carbon society with reduced CO_2 emissions, supporting sustainable development by developing uses of renewable resources for polymer production, polymers with new and/or improved properties and through energy-saving and environmentally friendly production technologies. The second major priority contribution will be in the area of health and quality of life. The goals of the programme are in agreement with the National Research and Development Programme (NRRP), as well as European directives in these areas. Cutting-edge science in the combined industrial-academic teams aims to make important contributions to future Slovenian competitiveness and sustainability in industry, knowledge and the environment.

Prof. Dr Majda Žigon, co-ordinator of the consortium

The programme of the centre is in accordance with the development plans of Slovenian polymer and related industries and is focused on four main themes in the most topical issues of global development. Several subprojects will be carried out within each topic. The four main areas are:

1) Technically advanced applications and energy. This topic is focused on the development of high-tech materials with high added value that will allow a quantum leap in certain technical applications. A key emphasis will be given to nanoscale developments where science and particularly applications have just started to deliver significant results while much more is expected in the future. The emphasis will be on nanocomposites and nano-organised materials that will allow the achievement of specific properties. Specific projects include:
   - ◊ Composite and nanocomposite materials with enhanced mechanical and optical properties on the basis of PMMA, PC and PET;
   - ◊ Photosensitive nanocomposites for applications in photonics and nanocomposites with ferromagnetic particles for applications in neutron optics;
   - ◊ Polymer composites with molybdenum and tungsten disulphides and with TMCH (TM is a transition metal, C chalcogen, and H halogen) nanoparticles for applications in solar cells;
   - ◊ Composite membranes based on polypropylene for the purification of water with enhanced filtering and mechanical properties;
   - ◊ Two- and three-phase composites with enhanced mechanical properties;
   - ◊ Passivation procedure of polymer-inorganic fibre composites for quality enhancement of commutators;
   - ◊ Hydrogenated carbon in fusion reactors.

Participating partners: NIC, Kolektor, IJS, UL-FMF, UM-FS, Kolpa.

2) Coatings and adhesives. The second area will primarily focus on the synthesis of functional polymers used in paints, coatings and adhesives. This area is of prime importance for the Slovenian chemical industry, which generates substantial sales from these materials. The emphasis will be on improved synthesis and reduction of organic solvents in production as well as technological processes, final formulations, and water-based formulations for advanced applications.

Specific projects include:

- ◊ Acrylic resins in organic-solvent solution with low volatile organic compounds content;
- ◊ Special copolymeric acrylate binders;
- ◊ New generation water-based dispersions;
- ◊ Adhesives.

Participating partners: Mitol, Helios, NIC, TBLUS, Kolpa, Akripol, Jub, Belinka.

3) Renewable resources, degradation and stabilisation. The topic will be devoted to the implementation of renewable resources for polymer production, as well as to degradation processes and stabilisation of natural or modified natural materials. The primary focus will be on biomass uses that include liquefaction and the modification and processing of products to serve as viable feedstocks for materials or fuels. A closely related emphasis is devoted to the study of degradation processes from the aspect of biomass transformation, biodegradation and preservation.

Specific projects include:

- ◊ Production of liquefied wood by new, innovative technologies;
- ◊ Adhesives and PU foams based on liquefied wood and other renewable resources;
- ◊ Waste PET for polymer synthesis;
- ◊ Methodology for determination of degradation of natural, synthetic and semi-synthetic polymers;
- ◊ Determination of rates of polymer biodegradation and establishing key effects;
- ◊ Stabilisation of paper with increased levels of transition metals.

Participating partners: NIC, GGP, Melamin, Mitol, UL-FKKT, TECOS, NUK, Belinka.

4) Polymers for healthcare and medicine. The main research directions will be: development of multifunctional materials for use in surgical care as well as faster post-operative treatment of superficial wounds, functional polymer surfaces with specific antithrombogenic properties for the manufacture of cardiovascular (vascular) implants, and biodegradable and biocompatible drug carriers, along with chromatographic macroporous polymeric materials for cleaning of biomacromolecules, such as peptides, proteins, viruses and DNA.

Specific projects include:

- ◊ Multilayer medical materials for effective healing of surface wounds;
- ◊ Improved biocompatibility of vascular grafts and stents;

Dr Andrej Kržan, managing director, CeO Polymer Materials and Technology.

Partners in the Centre of Excellence for Polymer Materials and Technology (CoE PoliMaT)

- National Institute of Chemistry, Ljubljana (NIC)
- University of Maribor, Faculty of Mechanical Engineering (UM-FS), Faculty of Chemistry and Chemical Engineering (UM-FKKT), Maribor
- University of Ljubljana, Faculty of Mathematics and Physics (UL-FMF), Faculty of Chemistry and Chemical Technology (UL-FKKT), Ljubljana
- The Jožef Stefan Institute (IJS), Ljubljana
- National and University Library (NUK), Ljubljana
- Polymer Technology College (VŠTP), Slovenj Gradec
- Akripol d.d., Trebnje
- Belinka Perkemija d.o.o., Ljubljana
- Bia Separations d.o.o., Ljubljana
- GGP, Gozdno gospodarstvo Postojna d.o.o., Postojna
- Helios Domžale d.d., Domžale
- Helios, TBLUS d.o.o., Količevo
- Kolektor group d.o.o., Idrija
- Kolpa d.d., Metlika
- Melamin d.d., Kočevje
- Mitol d.d., Sežana
- TC Polieko, Celje
- TRC Jub d.o.o., Dol pri Ljubljani
- Slovenian Tool and Die Development Centre, Celje
- Lek Pharmaceutical Company d.d.
- Tosama d.d., Vir
- Anteja ECG d.o.o., Ljubljana

TECOS

Assist. Prof. Dr Gašper Gantar, Managing director: "TECOS – the Slovenian Tool and Die Development Centre – is a non-profit organisation with the aim of supporting the Slovenian tool-making and production industry in becoming more successful in entering highly demanding markets. The mission of TECOS is the development and transfer of state-of-the-art scientific and technological knowledge in the areas of processing technologies into industrial practice. The main activities of TECOS are R&D, technological services for industry (development of new products and tools, optimisation of technological processes, advanced computer-aided technological services, industrial consulting), specialised training and networking activities for our members and partners.

TECOS is interested in the field of polymer materials, since more than half of all processed materials in Slovenia are polymers. Within the project, TECOS is responsible for the development of production processes, optimised for processing newly developed materials. This is a very important field, since the characteristics and quality of production processes significantly affect product characteristics, such as mechanical properties and costs.

By entering into the centre of excellence, we can take part in the basic research of new polymer materials and technologies for their production. We believe that the expected results from CoE PoliMaT will give us the opportunity of becoming a team supporting innovative companies in the development of new products."

- ◊ Drug carriers based on new PEG reagents;
- ◊ Macroporous polymers with controlled morphology.

Participating partners: UM-FS, NIC, UL-FMF, IJS, UM-FKKT, Lek, Bia Separations, Tosama.

All research directions are supported by combined teams of academic and industrial researchers and developers who will combine their different approaches and existing knowledge. Strong industrial involvement, which has led to a larger and more diverse consortium will act as a practical anchor for the ambitious scientific work. The consortium also has a number of companies, which all posses their own technology and will use the opportunity to make advances in it. The technological aspect is vital to the participation of partners, such as TECOS, specialising in tooling for the plastics industry.

Scientific excellence will be supported by new equipment, which will provide a solid basis for successful fulfilment of the programme and represents an important part of the planned budget. The equipment owned by the centre will be based in various locations, depending on the specific operational requirements, the major users and the opportunities to make it available to all partners requiring access. Several pieces of equipment will be larger in value and will represent a quantum leap that would otherwise be very difficult to achieve.

Sustainability is an integral part of all these avenues of research and results will be monitored during the progress of the project. Sustainability enters the programme in many aspects, most of these being indirect and leading to improvements in the final life-cycle balance of new materials. A significant effect is expected in reduced energy requirements during synthesis, processing and use, starting from feedstocks and solvents with a smaller environmental footprint, reduction of use of organic solvents, basing novel materials on renewable resources to allow for performance approaching CO_2 neutrality, and the additional option of biodegradation as the disposal process, which will allow plastics to be part of the natural material cycle.

In addition, all of these actions fit into a wider frame of development of the polymer field in Slovenia, with the emphasis on education, dissemination, networking and transfer of knowledge. The aim of the consortium will be to strengthen co-operation with the very disperse polymer community in Slovenia and abroad. Training and education are important priorities that will be addressed by the activities of the centre. All projects are planned to involve a university-level programme in which the state-of-the-art R&D work will be integrated into a hands-on curriculum offering students early experience in cutting-edge topics. The purpose is to enrich the educational programme and provide an organic link between the centre and its partners and students. Ultimately, this will lead to better education, improved job opportunities for young professionals and then opportunity to recruit staff for companies who are better prepared for work, and possibly already familiar with the core area of work.

The true basis for success in addressing key issues in the polymer field and society in general is excellence in science. The premise is that only excellent science can provide results capable of an impact on the environment, industry and society. To support scientific excellence, CoE PoliMaT is designed as an open, learning and growing structure, which will be increasingly involved in the European research area as well as globally. This will include the exchange of experts and permanent involvement of international experts on the scientific board.

The University of Maribor

Prof. Dr Karin Stana-Kleinschek: "The University of Maribor is a broad-based institution committed to excellence in education, the extension of knowledge through basic, advanced, and applied world-class research, and creative and artistic expression. With its complementary contributions to arts and sciences, law, business, engineering, medicine, and pedagogy, the university promotes cooperation, competition, and multi-disciplinary work. The university aims to promote partnerships with businesses, governmental and non-governmental, and other institutions in society to enrich university teaching, research and creative activity.

The Faculty of Mechanical Engineering, and the Faculty of Chemistry and Chemical Engineering are active partners in CoE PoliMaT and are responsible for co-ordination, and basic and applied research, within the health category. Together with our industrial partners, Tosama d.d. and Bia Separation, which will make a major contribution to developing new approaches in the field of materials used in medicine, we will be active on the following fields:

- development of a functional multi-layered material usable for treatment of surface wounds, based on study of the interaction of individual functional layers and their irreversible binding, while allowing retention of moisture and pathogenic microorganisms. For incorporation of functional groups (amines), the latest plasma technology will be used;
- improvement of haemocompatibility (antithrombogenity) of synthetic vascular implants, which have a remarkable impact on quality of life; preliminary results suggest the possibility of functionalisation by unbalanced gas radicals, which form stable negatively charged functional groups on the surface of artificial blood vessels, and thus dramatically inhibit fibrinogen transformation;
- in development of macroporous polymeric material (macroporous crosslinked polymeric monoliths based on metacrylate and styrene chemistry) for biomacromolecule purification and for carriers of catalysts and reagents, for which binding capacity and specificity with adequate mechanical stability are essential.

Our expertise, developed within the national and European projects in which we are involved as co-ordinators or partners, will support achievement of objectives within the health section of the partnership"

Kolektor Group

Radovan Bolko, managing executive director:

"The Kolektor Group is continuing its strategy of diversification and using synergies between the knowledge and capabilities of our different business and development programmes. Over the past few years, we have been focusing more attention on the development and use of new materials with improved mechanical, optical, electrical and magnetic properties. Our aim is also to find new materials that allow the introduction of innovative advanced technologies and that ensure higher production efficiency and quality of our products. In co-operation with institutions of knowledge within the CoE PoliMaT, we primarily wish to develop new knowledge in the use of composite and nanocomposite structures for applications in technical products for the automotive industry and household appliance technology."

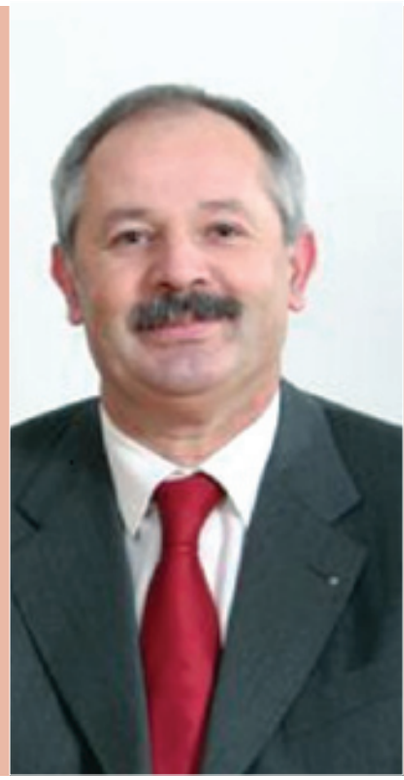
MITOL

Marjan Mateta,
managing director:

"The Mitol Adhesives Production Inc. company, located in Sežana, has 62 years of tradition in the production of adhesives and dispersions. The company's business strategy has always been directed toward ensuring a competitive position through a co-ordinated policy of marketing, development, and highly organised production. Research will continue to support the development of products that are in line with the newest trends in global markets and have higher added value. After Slovenia became an independent state, we sought out market opportunities in 25 countries – for us there has been no alternative to globalisation. Demands for protectionism come only from non-competitive environments. Business competitiveness and competitiveness of the economic environment are the only guarantees of success.

Through our involvement in the CoE PoliMaT, there will be faster and more intensive development of products in higher quality and price fields as a result of successful co-operation between researchers from various companies and academic institutions. Working within the framework of the CoE PoliMaT will also help us to achieve many of the more pressing goals of society. Access to new, modern R&D equipment through the CoE PoliMat will also form the basis for more efficient development of new products in the future.

New, innovative, environmentally friendly and energy-efficient market products will significantly improve the competitive position of all participating companies on the demanding global market. The effects should be apparent in a few years."



The Jožef Stefan Institute

Prof. Dr Miran Mozetič:

"The largest Slovenian research organisation has been supporting Slovenian industry with its R&D capabilities for decades. Participation in the CoE PoliMat programme will strengthen links with partners and allow for intensification of interdisciplinary research with the goal of development of new, high value-added and ecologically benign technologies. New technologies based on thermodynamically non-equilibrium processing of materials will result in the development of advanced materials with unique properties. Our work as part of CoE PoliMaT will enable upgrading of our analytical techniques for surface and thin-film characterisation, including high-resolution X-ray photoelectron spectroscopy and Secondary ion mass spectrometry. Together with electron and atomic force microscopy, a complete service for characterisation of surface films on advanced materials will be available to partners. Activities foreseen within the CoE will definitely strengthen the reputation of Slovenian science in the world."

University of Ljubljana Faculty of Mathematics and Physics,

Prof. Dr Irena Drevenšek Olenik:

"The University of Ljubljana (UL), with its more than 65,000 graduate and undergraduate students, and approximately 4,000 higher education teachers, represents an extensive pool of knowledge and resources in all fields of natural sciences. Its main contribution to CoE PoliMaT will be fundamental and applied research of new polymer materials and transfer of the associated new knowledge to the international scientific community, students, industry and the general public. The main expected benefit for UL is the creation of interdisciplinary links with other universities and research institutions participating in the centre of excellence and the establishment of active collaborations with industrial partners."

Melamin

Srečko Štefanič, General Manager: "The Melamin chemical company is a global supplier of synthetic resins for the rubber and paint industries. Since 1954, Melamin has been successfully developing innovative products and technologies meeting the highest industry standards. The future will bring new challenges in greater environmental awareness and long-term sustainability where renewable energy and material resources are vitally important.

Melamin chemical company has joined CoE PoliMaT to share resources and expertise with partners in research on natural polymer materials derived from renewable resources, especially wood biomass. We believe that CoE PoliMaT represents an opportunity for synergy between universities, institutes and industry in the area of cutting-edge research."

HELIOS

Dr Peter Venturini, Assistant Chairman of the Managing Board for Research and Development, Helios Domžale, d.d.:

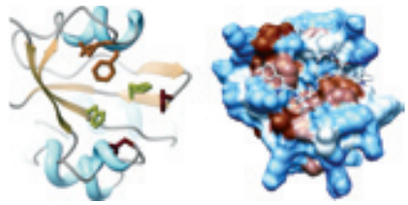
"Helios has high expectations regarding the CoE PoliMaT. The centre brings together partners with complementary knowledge in the area of polymer materials and technologies. The combination of existing knowledge and research equipment represents an excellent basis for the development of breakthrough products and technologies for the Helios Group. Within the CoE programme, Helios is particularly interested in the synthesis of polymer materials that will enable the development of a new generation of environmentally friendly coatings and coatings with special functional properties. We expect the centre to establish links with leading European and global R&D centres working on polymers and to be an important long-term partner of Helios."

CoE

Excellent NMR → Future Innovation for Sustainable Technologies

Janez Plavec and Rada Drnovšek

The Slovenian NMR Centre is one of eight Centres of Excellence (CoEs) selected following the call for proposals published by the Ministry for Higher Education, Science and Technology in 2009. As with every other CoE, the NMR CoE is organised as a consortium of several partners that will work in different fields, but with common goals. The NMR CoE will focus on two priority research fields, health and life sciences and advanced new synthetic metal and non-metal materials. It is important to underline that the Slovenian state is also encouraging all CoEs to follow the horizontal goal of developing future environmentally friendly and thus sustainable products by using less energy and consequently reducing emissions of carbon dioxide into the atmosphere. In fact, we have been encouraged to develop ecological prototype products, which can later be produced in the partner companies or sold to third parties. The general goal of our CoE is to deepen and broaden cooperation between research institutions and various innovative companies. With this kind of cooperation, we are trying to follow the goals adopted by EU countries in the Lisbon Strategy in 2000, which set some very ambitious goals in the economic, educational and research fields. Slovenia and the EU have big challenges ahead. We believe that CoEs can help in finding the right answers to these challenges. The knowledge and expertise available in the research institutions, on the one hand, and the will to take business risks in the companies, on the other, can contribute to significant breakthroughs in the coming years.



The NMR spectroscopy allows studying protein structures in solution at nearly in vivo conditions as well as exploring ligand-receptor complexes, which enable identification and characterisation of intermolecular interactions. Such new knowledge can significantly contribute to the design of new drugs. The NMR-derived high-resolution 3D structure of parvulin-like peptidyl-prolyl cis/trans isomerase from archaea Cenarchaeum symbiosum (CsPin) is shown on the left, while the model of its complex with YTPKW peptide is on the right.

PhD Janez Plavec

Rada Drnovšek

Dr Matjaž Polak MScBA, Director

Partnership between Krka and NMR centre

Rok Zupet, PhD

Krka was one of the founding partners of the National Centre for High Resolution NMR spectroscopy in 1995. Before this, Krka was the first company in Slovenia to have its own 60-MHz NMR spectrometer, which was bought in 1969 and at that time installed at the Faculty of Natural Science and Technology, University of Ljubljana. Since 1995, Krka has supported the development of the NMR centre by co-financing modernisation of the NMR spectrometers that are now installed and available for our research at the NMR centre at the National Institute of Chemistry. Recently, Krka purchased an additional high-field NMR spectrometer, located at the laboratory in Novo mesto.

Rok Zupet, PhD, R&D, Chemical development, Krka d.d., Novo mesto

The central element of Krka's strategic orientation is the manufacture of generic drug products. The basic activities involve production and selling of pharmaceutical drug products, which represent the majority of the operations involved. Krka's generic medicines are based on its own innovative synthetic processes or technology for the preparation or isolation of active substances, and on its own innovative pharmaceutical formulations. Today, Krka holds over 280 patented innovations, which have been applied in several European and Asian countries and in the USA. Owing to improved synthetic processes and evaluation methods, the active substance for a generic drug product may even be of higher quality than that of the original producer.

Krka did not hesitate when invited to the consortium for the NMR CoE. We believe that our cooperation through concrete projects will contribute to structure characterisation in solid-state pharmaceutical materials. The measurements and research of pharmaceutical materials in the solid state is of primary importance for the pharmaceutical industry as the majority of final pharmaceutical ingredients are crystal powders. Success in the development of new pharmaceutical materials is profoundly linked with understanding of the properties at the molecular and solid particle levels. NMR studies of new materials are indispensable in measurements of the crystalinity of solid materials, in characterisation and differentiation of various polymorphs, non-crystalline materials and solvated forms, and in demonstrating interactions between components in drug products. Along with identification and confirmation of the structure of the studied compound, NMR also enables identification and quantitative analysis of the main and side products (impurities) as well as characterisation of their 3D structures in the solid and liquid phases.

The next five years will be very important for the generic pharmaceutical industry, since drug products of substantial market worth are expected to go off patent. Krka has some targeted products in the development plan for new generic equivalent products. Krka's R&D activities in the field of new projects are focused on preparation of samples of new materials and f heterogenic formulation compositions for solid-state characterisations and interaction studies. A number of concrete projects will be studied and solved as part of the partnership with the NMR CoE in the coming years.

NIC as part of CoEs will contribute to the breakthrough of the Slovenian Economy and scientific Cooperation

Janko Jamnik

NIC made three applications for different CoEs to the Slovenian call for proposals and all were accepted. This result proves that the work of the NIC is recognised and well known and that we are on the right track to becoming one of the leading institutes of chemistry in Central Europe and beyond.

Janko Jamnik, PhD
Director of NIC

I believe that all three CoEs – CoE NOT, PolyMaT and CoE EN->FIST – are an example of effective co-operation between different companies and research institutions. The consortiums that were selected involve partners from different parts of the state, which helps to spread development work for the prototype products and disperse newly attained knowledge wider, which helps to develop the whole Slovenian economy. On the one hand, CoEs can be carriers of economic development, while on the other they can support companies that want to invest in development. The goals of all CoEs are ambitious but achievable.

NIC and the departments that are taking part in different CoEs will put all efforts into these projects, into regular co-operation and keeping all partners abreast of new ideas and any new results. I believe in the success of CoE NOT, PolyMaT and CoE EN->FIST and the development of their common work with business partners.

The NMR centre along with its partners will realise the programme of the CoE as an independent private institution called Excellent NMR Future Innovation for Sustainable Technologies, established by eight partners each of which has signed a consortium agreement and contributed to the application to the open call for proposals for CoEs. The National Institute of Chemistry, or more precisely the Slovenian NMR centre, is the co-ordinator of the CoE and works alongside two research institutions –the Jožef Stefan Institute and the University of Ljubljana Faculty of Chemistry and Chemical Technology. The other five partners (Krka d.d., Lek d.d., Betonal d.o.o., Optacore d.o.o. and Jeklotehna TEHO d.o.o.) are among the most developed Slovenian companies in the field of pharmaceuticals, construction and optical fibres. Together, we have set the goal of building a CoE that will be well equipped with modern research tools. Individual projects will be run by research personnel with expertise of international standards, recognised world-wide. Besides modernisation of equipment, the most important part of the CoE project is the education of students and younger researchers, who will now have the opportunity to be a part of multidisciplinary research groups and work side by side with experienced researchers, which will help them to gain more knowledge and experience. In fact, we believe that researchers and modern equipment are the pillars to research work that can follow or be in step with the most recognised research institutions in the world and can lead to higher added value.

CoE

The programme of the CoE consists of 16 research projects, which can be grouped into three research areas: a) pharmaceutical research projects, b) storage of hydrogen and c) MR imaging and development of new NMR probes. Each of the projects has the goal of contributing to a more effective response to the needs of industrial partners and to other environments, as well as contributing to the development of networks, maximising opportunities for joint research and research financing, encouraging partners to improve their qualifications and research expertise, increasing the possibilities for commercialisation, global expansion and the development of business plans and an innovative environment. One of the most important goals of the CoE is expanding knowledge about the possibilities of the use of NMR spectroscopy for various R&D projects and offering appropriate services to all that need them. A further strategic aim is to contribute to the development of new materials to support the hydrogen economy, including hydrogen storage and fuel-cell development. All of these activities are in compliance with world-wide trends of a shift towards hydrogen energy and thus towards a low-carbon society. The developed countries (USA, Japan, South Korea and the most developed EU countries) are investing significantly into development of a hydrogen-based economy, and this will also inevitably affect Slovenia. We believe that the two primary areas selected do not only offer opportunities for scientific breakthroughs, but also contribute to important advances and technological breakthroughs with transfer of the knowledge acquired to highly developed industrial partners.

R&D projects in the NMR CoE:

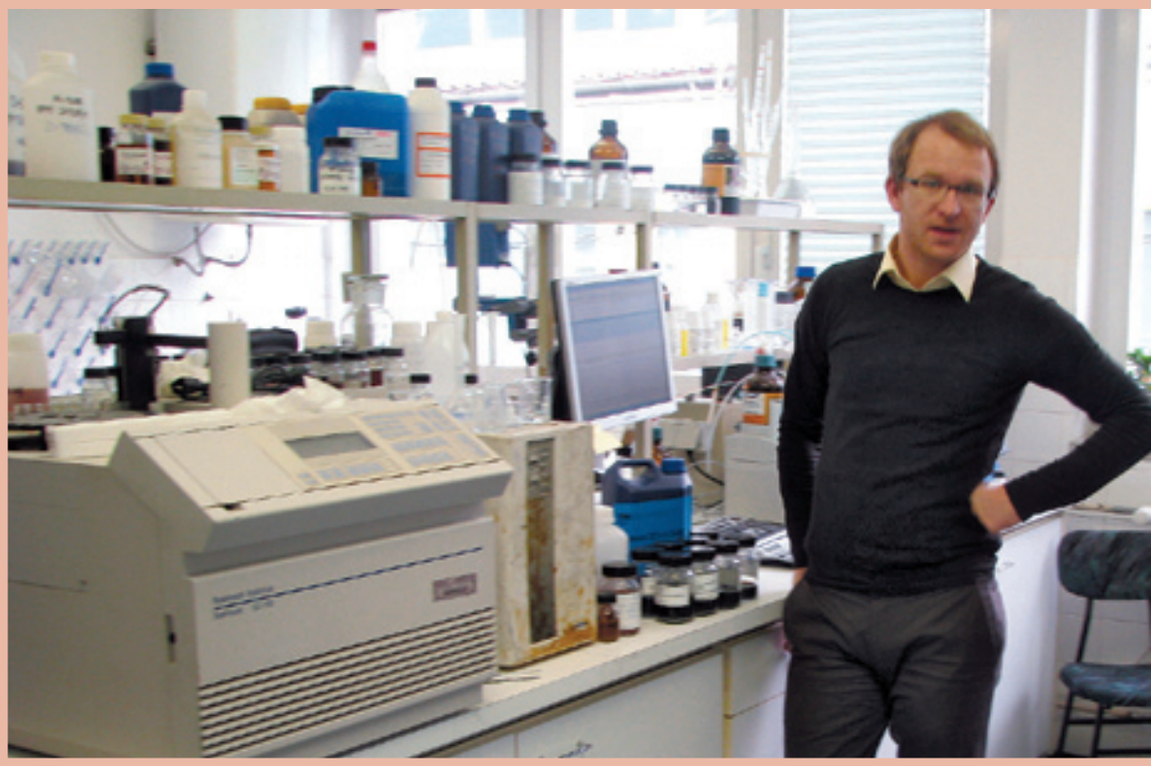
Structure and analysis of organic compounds in solution through NMR (P.I.: Primož Šket): The majority of medically active ingredients in clinical use today are small organic molecules. During synthesis, side products are produced in addition to the desired compound. Modern NMR methods have become one of the main tools of qualitative and quantitative determination.

Characterisation of recombinant proteins and biological macromolecules in aqueous solution (P.I.: Igor Zhukov): Our main focus is on proteins, mostly products of the human body, involved in vital cellular processes with respect to their potential medical applications. NMR spectroscopy enables us to obtain information about protein structure in solution at nearly in vivo conditions, taking into account temperature, ionic strength, pH, chemical modifications and binding of different substrates. In additionally, we can apply modern NMR techniques to obtain valuable information about molecular dynamics in protein, protein-protein and protein-DNA/RNA complexes in solution.

TKK Srpenica d.d.

Structural studies of polymer additives concrete

Luka Zevnik



Luka Zevnik, PhD, R&D Manager, TKK Srpenica d.d.

TKK is one of the leading producers of mineral and chemical admixtures for concrete, and polyurethane (PU) foam for special repair mortars in cans and sealants in the domestic market and markets of South-East Europe, and with PU foam world-wide, with exports to 55 countries. Our collaboration with the NMR Centre involves the use of NMR spectroscopic methods in studies of correlations between chemical structure, equilibrium compositions, molecular recognition and properties of compounds important for production and development of new materials.

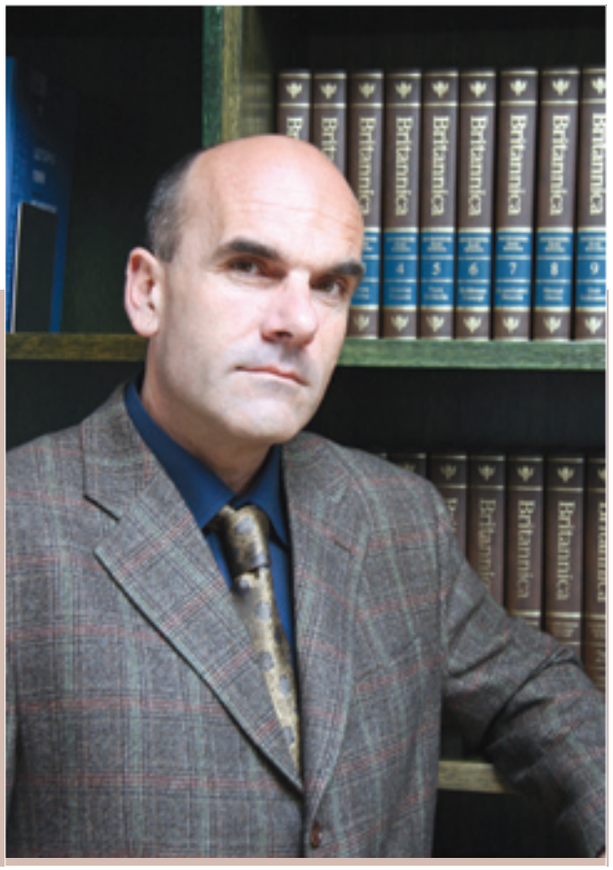
We have been working with the NMR centre for the past two years. With the help of NMR spectroscopy, we have established the microstructural properties of polycarboxylate polymers containing grafted polyethylene-oxide chains. Such polymers, called superplasticisers, are used to improve a number of properties of concrete in the fresh and hardened state.

Since we are not partners of the CoE directly, we are looking forward to becoming external partners and further developing our partnership with the NMR centre in the coming years. Our partnership with the CoE will hopefully result in the design of new polycarboxylate (PC) polymers, advanced synthesis of PC polymers and improving knowledge about the interaction of PC polymers with cement. The final aim of the partnership (which will last until 2013) is the development of a new generation of PC polymers for special applications, especially for ultra-high performance concrete, as well as in a construction material with a significantly reduced CO2 footprint, called “eco concrete”.

Solid-state nuclear magnetic resonance and studies of polymorphism (P.I.: Gregor Mali): “Within the project, we will study polymorphism in the field of pharmacy and investigate mesoporous silicate drug-delivery systems and interactions of active substances with either drug-carriers or excipients. Alongside more established techniques, we will extensively use high-resolution solid-state NMR spectroscopy and ab-initio calculations of NMR-detectable parameters.”

Interactions of new ligands with protein targets, rational drug design (P.I.: "Simona Golič Grdadolnik): "The formation of ligand-receptor complexes will be investigated by NMR methods that enable identification and characterisation of intermolecular interactions. A unique structural-dynamic insight into the differences in biological activity of novel ligands will be provided, which can significantly upgrade drug design studies based solely on rigid crystal structures."

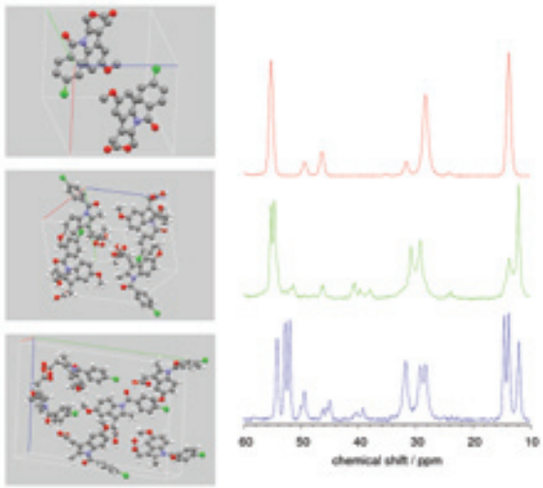
Synthetic biology (P.I.: Roman Jerala): "Synthetic biology represents an emerging approach to solving important problems combining engineering approaches with biological sciences. We will investigate molecular mechanisms of innate immune response as the first line of defence to develop new therapeutic strategies based on structural insights and principles of synthetic biology."



Nuclear quantum effects in enzymes, receptors and hydrogen-bonded systems (P.I.: Janez Mavri): "We are studying the dynamics of proton transfer processes in small hydrogen-bonded systems, enzymes and receptors. Our computational work is augmented with NMR spectroscopy, vibrational spectroscopy and pharmacological testing. Our research provides new insights into the nature of enzyme and receptor triggering; drug design is a direct application."

Asymmetric synthesis: Development of new chiral ligands for metal-promoted asymmetric transformations (P.I.: Barbara Mohar): "Our area of activity is asymmetric catalysis based on the use of metal-organic catalysts to access chiral molecules. Our focus is preparation and development of our own proprietary ligands and catalysts for industrial applications, for example in hydrogenation and transfer hydrogenation. Chiral nitrogen and phosphorus-containing ligands are being developed in our laboratory."

Figure 1. The majority of medically active ingredients in clinical use today are small organic molecules. Modern NMR methods, vibrational spectroscopy and hyphenated chromatographic-spectroscopic techniques have become the main tools for qualitative and quantitative analysis of such compounds. A pharmaceutical substance can, for example, crystallise in several different forms, which exhibit different physico-chemical properties. This phenomenon is called polymorphism and can be observed through NMR spectroscopy as shown.



NMR is a spectroscopic method that allows for study of correlations between structure, the sequence of (bio)(macro)molecules, dynamics and molecular recognition, and thus represents a route to insight into the biological functions, chemical structures and interactions in liquid and solid states, and the nature of fundamental processes that are important for production and development of pharmaceutical preparations and new advanced materials. This knowledge opens new biotechnological and biomedical possibilities, which can help to increase competitiveness, to develop and stimulate the innovation environment and contribute to progress in medicine. Novel materials for hydrogen storage will contribute to lowering of CO_2 emissions.

Qualitative and quantitative analysis of organic compounds with hyphenated techniques (P.I.: Irena Vovk): "For qualitative and quantitative chemical analysis in the fields of pharmacy, environmental protection, clinical chemistry, biochemistry etc., we will develop methods based on hyphenated techniques i.e. chromatographic techniques (LC, GC, TLC) coupled with spectroscopic (UV/VIS, MS, NMR) techniques, which predominate in modern analytics of organic compounds."

Vibrational spectroscopy of drugs and auxiliary substances (P.I.: Jože Grdadolnik): "The main objective of the work in this field is development of a methodology for application of vibrational spectroscopy (infrared, Raman, VCD and IRRAS) for structural studies of drugs and auxiliary molecules. These studies will be extended by implementation of modern techniques of vibrational spectroscopy for studying molecular interactions, drug encapsulation and delivery."

Study of drug delivery systems based on polymeric carriers (P.I.: Ema Žagar): "The project is focused on structural characterisation of polymeric drug delivery carriers, such as amphiphilic copolymers, hyperbranched polymers and dendrimers. We will study structural characteristics of conjugates in which low molar-mass drugs are covalently bonded to polymeric carriers. In the case of complexes, we will investigate non-covalent interactions between the drug and polymer."

Biologically active co-ordination compounds – synthesis, structure and properties (P.I.: Anton Meden): "Synthesis of complexes of natural antioxidants, zinc and cobalt complexes as model compounds for metalloenzymes, and novel biologically active ruthenium complexes, their precise structural characterisation in the solid state using X-ray diffraction and in solution using NMR spectroscopy, and assessment of the potential use of isolated compounds for therapeutic purposes."

Compounds for diagnostics and medical therapy (P.I.: Andrej Petrič): "The toolbox of modern synthetic organic chemistry, such as C-C bond formation catalysed by transition metals, direct arylation via C-H bond activation, and metathesis, will be applied for the preparation of novel compounds directed towards new or improved molecular probes and drugs for medical application."

Peter Jeglič

Janez Dolinšek

Martin Klanjšek

Nuclear magnetic resonance of new "smart" materials and Hydrogen energy - Towards low-carbon society (P.I.: Janez Dolinšek, P.I.: Martin Klanjšek, P.I.: Peter Jeglič): "The aim of these projects is to develop, synthesise and explore new metals-based materials that show "smart" physical properties such as the combination of high electrical conductivity with low thermal conductivity, the combination of hardness, elasticity and low friction coefficient, high hydrogen-storage capacity and the thermal memory effect for thermal inscription of digital information by pure temperature manipulation."

NMR probe development for research into complex materials with simultaneous ferroelectric, ferromagnetic or ferroelastic properties (P.I.: Alan Gregorovič in P.I.: Boštjan Zalar): "We are developing an enhanced-functionality NMR probe, which will be capable of applying RF magnetic fields, as conventional probes do, simultaneously with static electric fields, illumination, and strain. This functionality is required to study technologically promising multiferroic materials exhibiting simultaneous ferroelectric, ferromagnetic and/or ferroelastic properties."

Boštjan Zalar

Magnetic resonance imaging (P.I.: Igor Serša): "The MRI project group conducts basic science research in the development of new MR imaging methods, along with the following applicative fields: MRI in development of new controlled-release products, and MRI in the monitoring of food preparation, production and storage. In addition, the group provides educational and instrumental services for potential users."

The team of NMR centre

CoE NAMASTE

Advanced Materials and Technologies for the Future

Marija Kosec

The Centre of Excellence NAMASTE is a multidisciplinary and transdisciplinary consortium of research institutions and industry, who have decided to merge academic, technological and business expertise, skills, and equipment, with the aim of reaching crucial technological advancement in selected areas, related to inorganic nonmetallic materials and their implementation in electronics, optoelectronics, photonics, medicine, and by that to markedly increase added value, the relevance of research and scientific excellence, in line with development strategy for Slovenia. The centre directly fits into a strategic area in the National Research and Development Programme: advanced (new) synthetic metallic and nonmetallic materials and nanotechnologies and health and life sciences. The activities of the consortium include research, development, education, promotion; all of which involve protection of the environment and the possible transition to a low-carbon society. The consortium is balanced and consists of three research partners with eleven groups, three non-profit organisations, four large companies and nine SMEs :

- the Jožef Stefan Institute (Electronic Ceramics Department, JSI-K5;
- Department for Nanostructure Materials, JSI-K7;

Prof. Dr Slobodan Žumer (project leader RRP4), Assistant Prof. Dr Janez Štrancar (project leader RRP5).

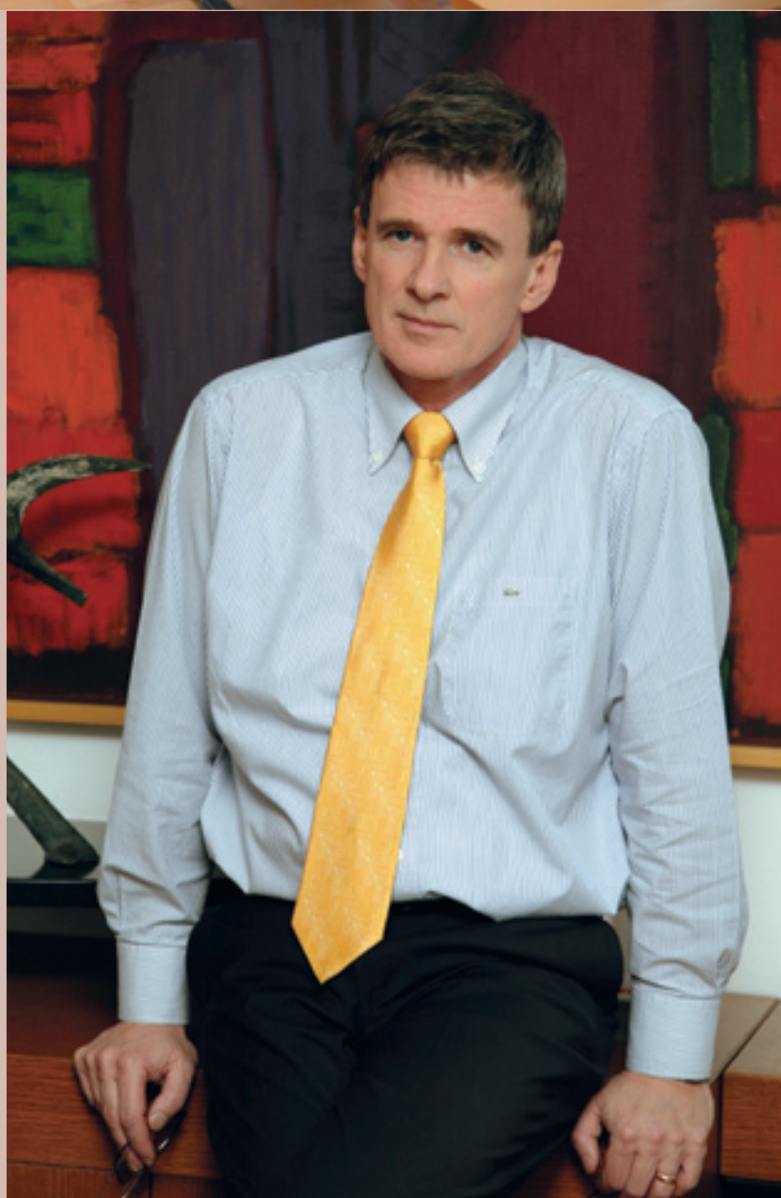
Dr Slavko Bernik (project leader RRP2), Dr. Janez Holc (project leader RRP1), Prof. Dr. Marija Kosec (director).

Prof Dr Janez Trontelj (project leader RRP3),

The Jožef Stefan Institute

Prof. Dr Jadran Lenarčič, Director: "The Jožef Stefan Institute is involved in all eight centres of excellence recently put into operation by the Slovenian Government. In three of these, the institute appears as the leading organisation and co-ordinator. These are the Center of Excellence in Nanosciences and Nanotechnologies, the Centre of Excellence for R&D in Advanced Non-metal Materials and Future Technologies, and the Centre of Excellence for Integrated Approaches in Chemistry and Biology of Proteins.

After too many years of relatively low level investment in R&D infrastructure in Slovenia, these centres of excellence mark a substantial step forward. Their main emphasis is on integrating and connecting basic and applied research from different research organisations and industries. For our institute, the centres represent a platform for future development of new scientific disciplines and themes strongly related to the technological needs of our companies to increase their international competitiveness and visibility. Through this infrastructure, collaboration between public and industrial research will be stimulated and mobility of research results will be support. The institute will be able to increase the number of direct projects with industry, while our industrial partners will have greater access to the institute's international networks."



Condensed Matter Physics Department, JSI-F5;
- Engineering Ceramics Department, JSI-K6);
- the University of Ljubljana (Faculty of Electrical Engineering, UL-FE (Laboratory for Microelectronics, LMFE;
- Laboratory for Microsensor Structures and Electronics, LMSE);
- Faculty of Mathematics and Physics, UL-FMF;
- Biotechnical Faculty, UL-BF;
- Veterinary Faculty, UL-VF;
- Faculty of Medicine, UL-MF;
- Faculty for Chemistry and Chemical Technology, UL-FKKT);
- the University of Maribor (Faculty for Chemistry and Chemical Technology, UM-FKKT);
- HIPOT-R&D Research and Development in Technologies and Systems, d.o.o.;
- TC SEMTO Development Centre for Circuits, Components, Materials, Technologies and Equipment for Electrotechnic;
- the Nanotesla Institute, the R&D Center for Nanotechnologies in the Field of Magnetic Materials and Composites; Iskra Avtoelektrika d.d.;
- ISKRA TELA, Proizvodnja anten, baterij, industrijske elektronike in galvanotehnika, d.d.;
- ISKRAEMECO Energy Measurements and Management, d.d;
- ETI Electroelement d.d.;
- HYB Production of hybrid circuits;
- KEKON Ceramics Capacitors, d.o.o;
- KEKO Equipment d.o.o;
- VARSI d.o.o., varistor manufacturer;
- Iskra ZAŠČITE d.o.o., surge voltage protection systems, engineering and co-operation;
- KOLEKTOR MAGMA Magnetni in nanomateriali d.o.o.;
- BALDER, Optoelectronic Elements and Measuring Systems, Ltd.;
- MESO IZDELKI JOŽEF FINGUŠT s.p.;
- NANOTUL d.o.o.

The centre is divided into three work segments. The first, "development and management of the centre" includes leadership, management, and promotion, and is the responsibility of high-quality external col-

The Significance of the Centre of Excellence NAMASTE for ETI

ETI Elektroelement d.d.

Mitja Koprivšek, MSc,Strategic R&D manager: "ETI Elektroelement is one of the world's leading manufacturers of devices for the protection of low and high-voltage electrical installations both in the field of fuse links and circuit breakers. Knowledge in depth of technology in the production of individual components continues to be a major condition for competitiveness in this field, including the development and production of ceramic materials for all types of fuse-link housings. ETI originated from the ceramics production started in Izlake 60 years ago. Non-metallic or ceramic materials thus represent a key competence for the company in achieving a competitive position in the market.

Co-operation in the Centre of Excellence

laborators. The second, "research and development projects" (RRP), contains six projects:

- RRP1: Ceramic 2D and 3D structures (Dr Janez Holc),
- RRP2: Materials for overvoltage and EM protection(Dr Slavko Bernik),
- RRP3: Materials, micro- and nano- systems for sensors(Prof. Dr Janez Trontelj),
- RRP4: Soft composites for optical, electronic, photonic and sensor applications(Prof. Dr Slobodan Žumer),
- RRP5: Bioactive, biocompatible and bioinert materials(Assistant Prof. Dr. Janez Štrancar), and
- RRP6: Project of new opportunities(Assistant Prof. Dr Danjela Kuščer Hrovatin), which is designed to allow for inclusion of new partners.

There are many possibilities of synergy between the projects. The third work segment, "implementation of new R&D equipment" is of extreme importance for the centre. In our view, the centre has very strong foundations for success, because of the excellence of the research partners involved, the technological and business excellence of the industrial partners, and above all, because of the confidence between partners, which stems from previous collaboration within the Centre of Excellence: Materials for electronics of future generations and other emerging technologies. This centre was ranked among the top 5% in Europe by the independent reviewer.

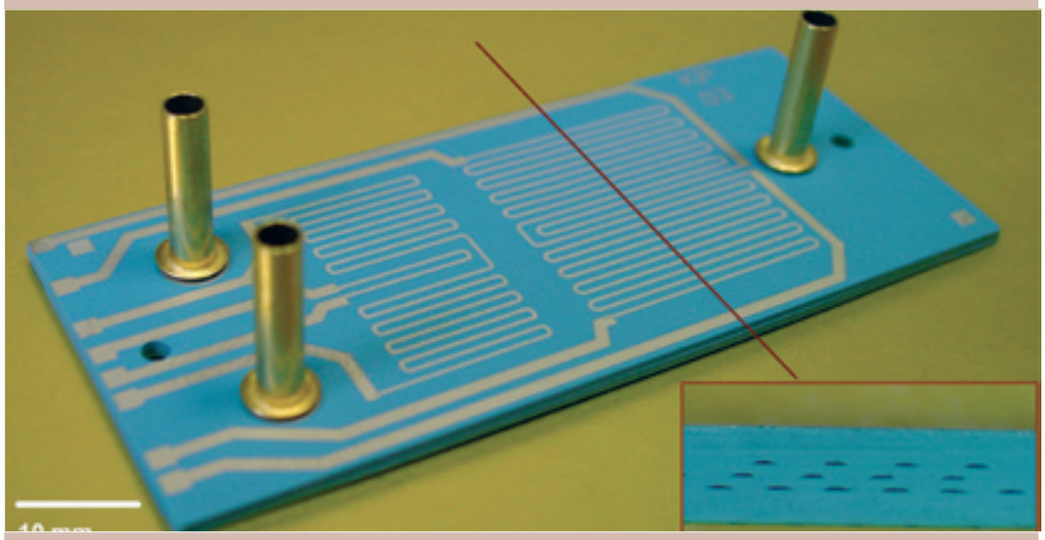
NAMASTE will help ETI in several ways. Its organisation will maintain a critical mass to achieve the level of the latest knowledge in this field, and implement target-oriented development projects. ETI experts will develop and deepen their knowledge, along with other members of the centre of excellence. Above all, activities in this centre will provide for faster acquisition of new knowledge, which is of critical importance for successful implementation of projects related to new products with higher added value. In the future, ETI is planning several projects, in the field of fuses and in fields related to power generation, renewable energy sources and other industrial fields, e.g. the automotive industry and industries related to ecology and waste management. In short, ETI – a major industrial company – will play a highly active role in the Centre of Excellence NAMASTE.

Research Challenges – Ceramic 2D and 3D structures

Low-temperature co-fired ceramic (LTCC) technology is especially convenient for ceramic microsystems. LTCC materials in the green state (called green tapes, before sintering) are soft, flexible, and easily handled and mechanically shaped. A large number of layers of these materials can be laminated to form high-density interconnections and three-dimensional structures, such as cantilevers, bridges, diaphragms, channels and cavities. These laminates are sintered in a one-step process (co-firing) at relatively low temperatures (850–900°C) to form a rigid monolithic ceramic multilayer module.

At the sintering temperature, the LTCC material is reactive due to the presence of low-melting-point glass. Because of this, the integration of the active and passive layers into the LTCC structure is a significant challenge. The reaction between components changes their functional characteristics when integrated.

Current LTCC technology is mostly oriented towards single devices or systems of conventional devices. Complex systems or systems with extreme parameters are very rare. We are planning to develop materials and processes for the fabrication of complex systems and systems with extreme parameters, such as LTCC structures with a large cavity and thin walls (cavities with diameter larger than 20 mm and diaphragm thickness less than 100 mm) and, for the first time, integration of lead-free piezoelectric material into LTCC structures. This technology will be demonstrated within this segment, which will later potentially be of interest for industrial applications.



A ceramic micro-chemical reactor is assembled from eight LTCC layers. It contains buried channels in several layers. The width, thickness and length of the channels are 400 m, 30 m and nearly 2 m, respectively. Thick-film Pt-based heaters are printed and fired on the surface. The inlets for reactants are on the left and the outlet for reaction products on the right. The microstructure of the cross-section of the channels is shown on the right.

The Centre of Excellence NAMASTE is also an opportunity for the industrial partners

Hyb d.o.o.

The Hyb Company is a Slovenian high-tech enterprise of medium size. The company has a long tradition in electronic circuits (modules) based on thick-film hybrid technology. The plant in Šentjernej was founded in 1972, when the first electronic circuit using thick-film technology was produced. In the mid 1980s Hyb started production of invasive blood-pressure sensors and in the late 1980s with industrial pressure sensors and transducers. In 2001, the company was bought by Novoline Holdings. The owner invests a great deal in technology, facilities, development and marketing. Today, Hyb is a modern, future-oriented company. Its business philosophy is based on marketing, development and production of pressure sensors and electronic modules based on thick-film hybrid technology. The largest segment of Hyb's products is medical applications, followed by automotive and industrial segments. In the field of medical sensors, Hyb develops and produces invasive blood-pressure sensors that take approximately 6% of the world market. At the same time, a new generation of sensors and complementary medical programmes are in the development phase.

One of these future programmes is based on the low-temperature co-fired ceramics (LTCC) technology, for sensor and other microsystem applications. These so-called ceramic microsystems are an innovation in the market and are a subsection of microsystems technology. This technology is bringing together such different basic technologies as mechanics, fluidics, optics, electronics and new materials. For the economic aspect, it is important that microsystems technology and resulting products play an increasing role across the complete value chain (from research, technology, development, manufacturing, etc.) in different application areas. From the European perspective, it is important that microsystems technology has an explicitly multidisciplinary character, which in the past gave an important competitive advantages to players from Europe in comparison with others.

Dušan Plut, General Director of Hyb

The development of ceramic microsystems required the construction of three-dimensional structures for LTCC ceramics, the integration of different functional materials into the structure, and of electronics for system control. Success depends on following: (i) interdisciplinary applied research of complex microsystems in the fields of materials, ceramic technologies, thick-film technology, mechanics, electronic components, design and realisation of systems; (ii) development of new materials and equipment; (iii) technology transfer from the laboratory to industrial scale; (iv) cooperation with customers and other marketing activities. Hyb sees most of these activities as part of th project on two- and three-dimer sional ceramic structures, which i a part of the Centre of Excellenc NAMASTE. The consortium for th project consists of three researc partners: the Jožef Stefan Institut (Electronic Ceramics Department the University of Ljubljana (Facult of Chemistry and Chemical Techno ogy) and HIPOT-RR; alongside thre industrial partners: KEKO Equip ment, KEKON and Hyb. The mem bers of the consortium are experts i their own field and as a consortiu cover the complete value chain fro theoretical and experimental basi research to development of mate

Technology Centre SEMTO's integration in the Centre of Excellence NAMASTE

Jožef Perne

The mission of the Technology Centre SEMTO is to integrate knowledge between institutes, faculties and industry. SEMTO includes 28 members, with around one third from the development sphere and two thirds small, medium and large companies. The SEMTO centre looks for opportunities for its members in R&D projects, encourages innovation in companies with concrete measures, and co-operates in the preparation of applications for co-financing of research activities. The centre works to find relevant knowledge and relations with knowledge institutions for each development project from its industrial members.

Work as part of the Centre of Excellence NAMASTE offers SEMTO a great opportunity for knowledge integration. The projects of the centre of excellence are the result of connections between industry and the research world. The centre will mostly create new relations that will be maintained after completion of projects within the centre of excellence. I am certain that the consortium of companies and institutions integrated in the centre of excellence stands at the top level of knowledge in the field of non-metallic materials. Critical mass in the narrow professional field of non-metallic materials is achieved through collaboration of all who possess relevant knowledge in Slovenia and are ready to continue investing, and those who are successfully implementing such knowledge in practice by integrating it in their products. The partnership in the centre of excellence represents a good starting point for companies wishing to reach a higher technological level with their products. These could be elements, units or devices, since the development of new materials in many cases offers the basis for improving the properties of such products and also for completely new product functionality, such as in the case of nano-materials and nanotechnologies.

All those working together in the centre of excellence will be faced with new challenges in the coming years. In addition to good knowledge, we must implement excellent project management. This will result not only in direct R&D targets, but also in improved knowledge in other fields including project management and strategic planning in companies i.e. wherever competitiveness in the market can be improved and added value increased.

Jožef Perne
Director of Technology Centre SEMTO

rials, technology, equipment and devices.

Participation in the Centre of Excellence NAMASTE is not only an obligation but also offers many opportunities for the industrial partners. The most important opportunities for Hyb are in bridging the gap between the research and industry, to form a value chain and to work with excellent partners, to access to up-to-date technology, access to the European research area, and funding of research activities. In our case, the Centre of Excellence NAMASTE will act as a launchpad for innovative ideas.

Activity within the centre will be oriented not only towards technological innovations (design, processes and materials), but also to higher efficiency and lower energy consumption of technological processes. This will contribute also to reduction of CO2 emissions in the environment. Hyb also sees business opportunities in the future to develop devices for market that will be designed from the start as low energy-consumption components.

Iskraemeco
and the Centre of Excellence NAMASTE

Uroš Bizjak

The goals of Iskraemeco in the Centre of Excellence NAMASTE are to acquire the necessary knowledge, skills, circuits, technologies, architectures and algorithms for its future advanced sensor measurement system, which will be capable of precision measurements of electrical energy, power and other parameters of the mains network. The main research partners are LMFE (the Laboratory for Microelectronics at the Faculty for Electrical Engineering, University of Ljubljana) and the R&D department of Iskraemeco. Each partner will have specific responsibilities and goals.

Dr Uroš Bizjak is responsible for the project within the centre in Iskraemeco and explains the main goals of the project from the industrial partner's perspective.

The implementation of the whole measurement system on a single silicon ASIC is expected to make the system considerably cheaper, smaller and more reliable, because of the smaller number of components needed to build the instrument. In addition, the use of modern technology will reduce the power required by the instrument; taking into consideration the number of meters used in the world, this reduction can help to reduce overall electrical power consumption significantly. By designing its own ASIC, Iskraemeco expects to gain a market advantage because of the use of customised solutions not available on commercially available ASICS. By the system on chip (so) developed, the customer will gain a reliable and efficient solution for measurement electrical energy at each measurement point. Integrating sensitive analogue signal processing and DSP on the same chip will provide measured parameters that are not usually available and could add additional value to the products. Because of the expected very low price and small dimensions, it will be possible to build systems of this kind into more devices, and thus to better manage energy consumption.

A smart power meter is only part of a bigger system for measurement and management of electrical energy. The system combines knowledge from the field of precision measurements, signal processing, algorithms, communications, networks and protocols, and technology. The goal of Iskraemeco is to have a complete set of solutions available for the customer, and thus to become a leading supplier of electrical-energy management and measurement systems in the near future.

Building a smart power-metering device is a complex measurement, communication and management activity. It requires interdisciplinary knowledge. Firstly, a detailed knowledge of modern CMOS technologies, together with relevant strengths and weaknesses, including knowledge of appropriate architectures, algorithms, and design techniques to fulfil the difficult requirements of a precision measurement system. Secondly, it requires detailed knowledge of electrical-energy measurements, industrialisation and energy management. The first part will be the responsibility of the LMFE, and the second of Iskraemeco.

Since precision measurement is the key element of a smart-power metering/management system, it will be necessary to find appropriate architectures, circuits and algorithms to use the sub-100nm CMOS technology that is required to build the whole system on one chip (SoC). A number of new solutions (not currently available) will be needed to be able to build such a system in sub-100nm CMOS technology because of the limited dynamic range, reduced supply voltage, large thermal and 1/f noise and integration of significant DSP on the same chip. In addition, sub-100nm CMOS technology offers "lossy" transistors – the basic building blocks; high-precision modules are difficult to build with these elements and appropriate DSP algorithms must be used to correct the basic behaviour of the "analogue" elements; new module architectures must also be found. In addition, integration of the whole system will cause problems related to efficient testing, reliability, verification and on-demand field-testing, which will require new RTBIST (real-time-built-in-self-test) circuits and algorithms, new test algorithms, etc. The research activity will thus give the basis for the development of the smart –power-metering system in sub-100nm CMOS technology.

Dr Drago Strle is responsible for the research and development part of the smart-power metering project within NAMASTE in LMFE.

Iskra Zaščite
for the Centre of Excellence NAMASTE

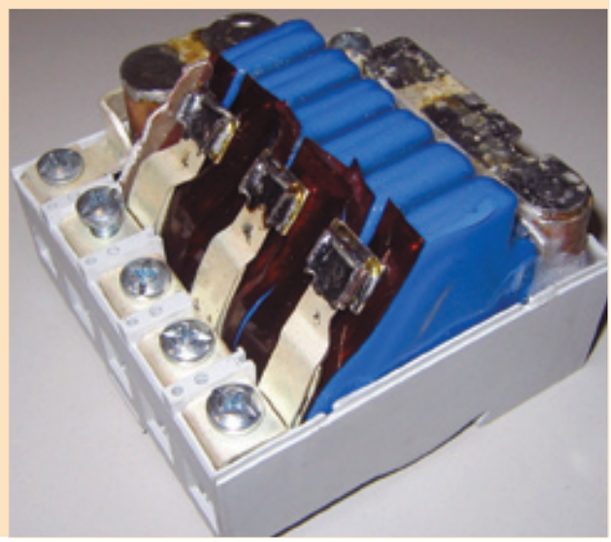
Aleš Štagoj MSc, Head of R&D:

"Iskra Zaščite is today one of the Europe's leading suppliers of surge-protection devices (SPDs) for power, data and telecommunications.

Electrical and electronic equipment and devices, information and telecommunication technologies are part of everyday life, both at work and in our homes. Their undisturbed use is essential in many ways and can be ensured only with the use of high-quality devices for protection against transient surges, which mostly result from lightning strikes and also electrostatic discharges. Within the Centre of Excellence NAMASTE, Iskra Zaščite will contribute its latest solutions, based on combinations of ZnO-varistors and gas discharge tubes (GDT), for the construction of highly efficient SPDs.

The objectives of the project are improved and new materials, new knowledge and new technologies to support the development of elements and devices for the next level of overvoltage and EM protection. With the development of new miniaturised GDTs, which are of key importance for the miniaturisation of SPDs, while maintaining efficiency and reliability, Iskra Zaščite will realise reduced production costs and energy savings.

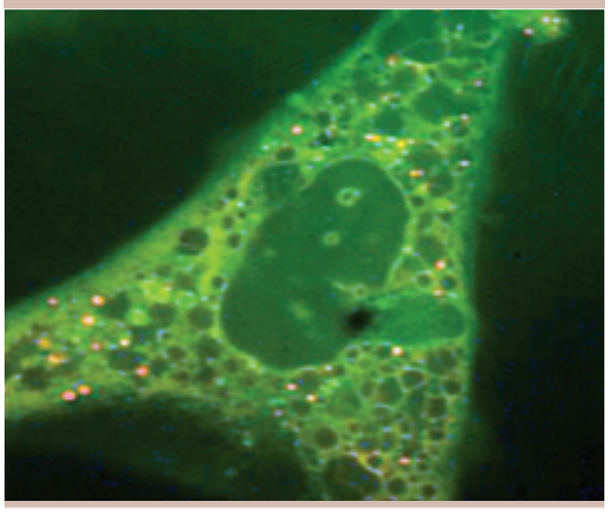
The project will enable optimal use ofhumanresources and the specific skills, experience and knowledge of researchers and different research teams, along with their equipment. This will strongly contribute to successful and faster realisation of our project goals. The most important aspect of the project is sharing equipment among the partners in the project, plus assistance for their use. Another important element is the purchase of new equipment for surge testing, which is required for successful realisation of this project, as well as for Iskra Zaščite R&D activities in the long term.



Research Challenges: Bioinert, Biocompatible, Bioactive Materials

Development of novel materials and functionalised surfaces opens new opportunities, from bioinert to bioactive materials, including antimicrobials, which could potentially replace environmentally harmful (bio) chemical substances. Nanomaterial coatings tested in laboratories have already proved the feasibility of a new concept of protection against pathogenous bacteria. But this is far from guaranteeing safe usage, as these materials must sooner or later make close contact with the human body. Therefore, they must be tested for interactions with our body tissues and cells, plants and animals. At the same time, applications should try to localise these materials as much as possible, to allow these materials to serve us where we really need them. In the world of novel materials and developing technologies, preventing hidden threats to health and environment should be the main priority. But is it currently? Numerous projects in the EU and USA suggest that the research community is mostly concerned with bringing technologies to market. However, since this whole area of research is relatively new, we are working to offer solutions and new functionalities for these materials, together with a guarantee of their safety, and to standardise the process of testing of their safety.

Within the Centre of Excellence NAMASTE, we have joined research profiles of material sciences, natural sciences, biotechnology, medicine and veterinary sciences, to encourage development of new human-healthy bioactive, biocompatible and bioinert materials. It is not our intention only to protect the food-processing industry by preventing against contamination with harmful bacteria such as Listeria monocitogenes or to offer novel (and more resistant) ceramic materials for dental or bone treatments, but also to point to the long-term safety and biocompatibility of these new materials and technologies.



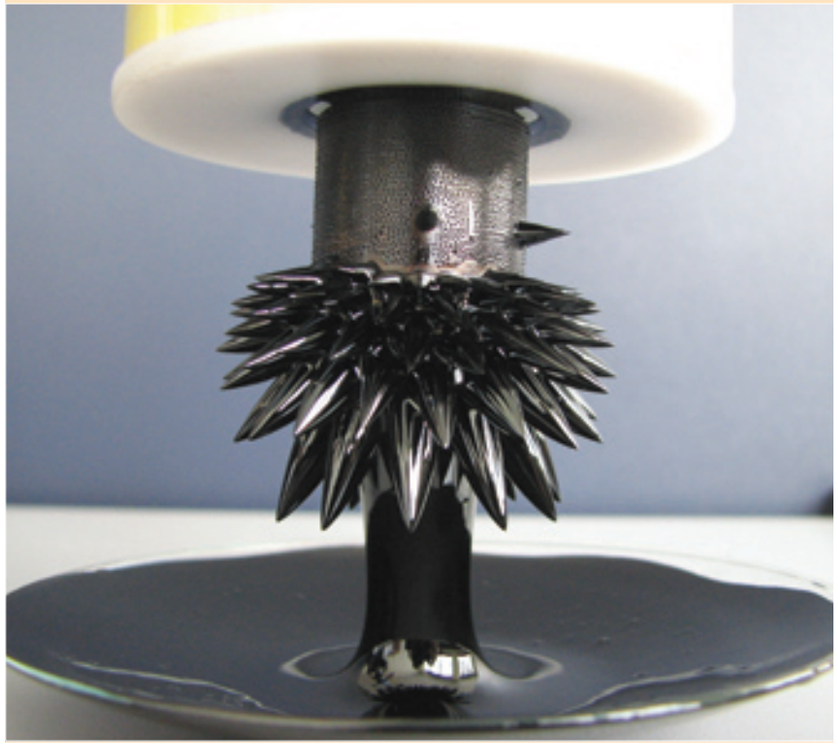
The Nanotesla Institute

Assist. Prof. Dr Andrej Žnidaršič: "Our institute was founded in 2006 by several industrial companies (Kolektor Group Idrija, Iskra Feriti Ljubljana and Magneti Ljubljana) to perform R&D in nano-materials and nanotechnologies, to participate with research institutions and to assist in the transfer and introduction of new technologies. The institute operates primarily in the areas of nano-materials for coatings with a self-cleaning effect, coatings with an antifouling effect, temperature- and fire-resistant coatings, nano-magnetic materials for biomedical in the field of in-vivo target drug delivery in cancer therapy, materials for microwave applications, composites based on thermoplasts and duroplasts, and microwave characterisation of materials.

The extremely rapid worldwide progress in nanoscience and nanotechnology crucially relies on new technologies for creation, study and control of matter on the scale of atoms and molecules. The project included in the Centre of Excellence NAMASTE is designed to address the challenge posed by extremely rapid development of advanced materials and technologies in the world, by joining together the efforts of all leading research groups and industry leaders in the field in a consortium whose single goal is to set up technological infrastructure for the competitive development of advanced materials and technology in Slovenia in the next decade.

The key expectations of the centre are:

- to include all leading teams in the country working on advanced materials, from academia, government research labs and leading industries;
- to establish systematic facility support, to ensure transparent and easy access to young academic researchers from diverse fields and researchers from industry;
- to develop, through acquired knowledge and technologies, new products with a higher level of integration, innovative solutions and new functionalities, and thus to significantly improve the market position of participating companies and partners.



Kemijski inštitut, Ljubljana, Slovenija
1001 Ljubljana, Hajdrihova 19, p.p. 660

Employees

The National Institute of Chemistry has 273 employees, of which around 185 carry out research work in 15 laboratories and two infrastructure centers; 124 of these have doctorates of science. Approximately 60 "young researchers" are involved in educating at the Institute in 2010.

Research

Basic and applied research are oriented towards fields that are of long-term importance to both Slovenia and the world: molecular biochemistry, structural and computational chemistry, biotechnology, materials research, chemical engineering, environmental protection and analytical chemistry, through which the Institute is in line with the needs of the domestic chemical, pharmaceutical, tire, and food industries. The work of the Institute is also in line with the priority thematic areas of the 7th Framework Program of the EU, which places emphasis on genomics and biotechnology for health, nanotechnology, quality and safety of food, as well as nutrition, sustainable development and global change.

Education

The Institute aims to enable young researchers to work in current fields of research, as well as to groom them for leading positions in the public and private sectors. The Institute works with Slovenian universities as well as international educational institutions in order to realize these goals.

Cooperation with industry

Research is oriented towards the development of new technologies and products, which are internationally relevant and will help to ensure the long-term development of Slovenia. Industry is an important partner to the Institute in these endeavors. There are a number of Slovenian companies with whom the Institute has entered into close long-term cooperation, including a number of well-regarded foreign companies.

Contact with world science

The Institute offers high-level research equipment, allowing researchers to engage in even the most cutting edge research challenges at the world level. The most recent acquisitions are: a Karl Zeiss Supra 35 VP Electronic Microscope with EDX analysis, a high resolution powder x-ray diffractometer, and an 800 MHz NMR spectrometer; these are the only of their kind in Slovenia. The NMR spectrometer is the first of this kind of instrument to be found in the new member states of the EU and represents one of the largest investments in a free-standing piece of research equipment in Slovenia.

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